Vol. 38, No. 4 July, 1931

PSYCHOLOGICAL REVIEW PUBLICATIONS

Psychological Review

EDITED BY

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PUBLISHED BI-MONTHLY
FOR THE AMERICAN PSYCHOLOGICAL ASSOCIATION
BY THE PSYCHOLOGICAL REVIEW COMPANY
PRINCE AND LEMON STS., LANCASTER, PA.
AND PRINCETON, N. J.

Entered as second-class matter July 13, 1897, at the post-office at Lancaster, Pa., under Act of Congress of March 3, 1879

PUBLICATIONS

OF THE

AMERICAN PSYCHOLOGICAL ASSOCIATION

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Review, Bulletin, J. Exp., and Index: $18.00 (Foreign, $18.75).

Subscriptions, orders, and business communications should be sent to the

PSYCHOLOGICAL REVIEW COMPANY

PRINCETON, N. J.

VOL. 38, NO. 4 July, 1931

THE PSYCHOLOGICAL REVIEW

AGAIN THE JAMES–LANGE AND THE THALAMIC THEORIES OF EMOTION

BY WALTER B. CANNON

From the Laboratories of Physiology in the Harvard Medical School

In an article in this REVIEW last year Newman, Perkins and Wheeler [1] criticized and commented upon an examination of the James-Lange theory of emotion which Cannon published in 1927 [2] and also raised objections to an alternative theory then offered which would place the source of the affective elements of experience in the thalamic region of the brain stem. In their article there are so many indications that the authors misapprehended the points in the argument that a survey of these points seems called for. In order to make the situation clear, I shall use two diagrams (see Figs. 1 and 2), understanding, of course, that they represent a great simplification of intricate arrangements in the nervous system. With these diagrams for reference the chief features of the two theories can be briefly summarized and compared.

THE TWO THEORIES

The James-Lange Theory.—According to the James-Lange theory an object stimulates one or more receptors (*R*, Fig. 1), afferent impulses pass to the cortex (path 1) and the object is perceived; thereupon currents run down to muscles and viscera (path 2) and alter them in complex ways; afferent

[1] E. B. Newman, F. T. Perkins and R. H. Wheeler, Cannon's theory of emotion: a critique. PSYCHOL. REV., 1930, 37, 305–326. Absence in Europe, illness and accumulated duties have prevented an earlier reply to this article.

[2] W. B. Cannon, The James-Lange theory of emotion: A critical examination and an alternative theory. *Amer. J. Psychol.*, 1927, 39, 106–124.

impulses from these disturbed organs course back to the cortex (paths 3 and 4) and when there perceived transform the 'object-simply-apprehended' to the 'object-emotionally-felt'; 'the feeling of the bodily changes as they occur is the emotion —the common sensational, associational and motor elements explain all,' to quote James's expression.

Evidently this theory does not regard important ana-

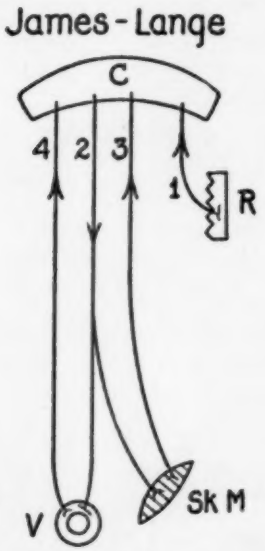

FIG. 1. Diagram of nerve connections in the James-Lange theory.

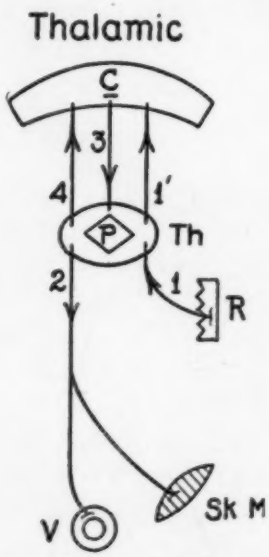

FIG. 2. Diagram of the connections in the thalamic theory.

R, receptor. *C*, cerebral cortex. *V*, viscus. *Sk M*, skeletal muscle. *Th*, thalamus. *P*, pattern. The connecting lines represent nerve paths, with the direction of impulses indicated in each instance. Cortico-thalamic path 3, Fig. 2, is inhibitory in function.

tomical and physiological facts. In the thalamic region [3] all afferent paths (optic, acoustic, touch, temperature, pain, proprioceptive sensibility, etc., except the olfactory) are interrupted [4]—the theory does not take into consideration that primary fact and its large possibilities for regrouping afferent impulses at the thalamic level and distributing them. The

[3] The expression, 'thalamus' or 'thalamic region,' is used here to include not only the sensory stations in the various parts of the diencephalon, but also the motor centers (*e.g.*, the hypothalamus).

[4] C. J. Herrick, An introduction to neurology, Philadelphia, 1924, p. 179.

thalamic region contains elaborate association paths and motor coordination centers and can discharge impulses widely into the viscera and into skeletal muscles [5]—the theory does not recognize that fact which is highly significant for the interpretation of behavior. The thalamic region has innumerable neurone connections afferent to the cortex, and processes in the thalamus can markedly affect conscious states [6]—the theory is oblivious of that fact, which is especially pertinent for a concept of emotion because thalamic processes can give rise to emotional expression. As Herrick [4] (p. 344) has remarked, relative to the thalamus, "no simple sensory impulse can, under ordinary circumstances, reach the cerebral cortex without first being influenced by subcortical correlation centers, within which complex reflex combinations may be effected and various automatisms set off in accordance with their preformed structure." All these considerations are wholly neglected in the James-Lange theory and by its supporters. It should be evident that in so far as a theory fails to recognize relevant facts it is defective.

The Thalamic Theory.—As shown in Fig. 2, the thalamic theory admits the anatomical organization which the James-Lange theory ignores—the interrupted afferent path, the connection with the cortex, the internal pattern or 'preformed structure,' and the efferent courses to skeletal muscles and viscera. Associated with these structural arrangements are functional phenomena of prime interest to a theory of emotion.

The thalamic region is a coördinating center for so-called 'emotional' reactions. This statement is based on the observations (*a*) that after removal in lower animals of all of the cerebrum anterior to the thalamus the behavior commonly designated as 'rage' is exhibited; and when in addition the thalamus is removed the reaction disappears; [5] (*b*) that a tumor affecting one side of the thalamus in man results in unilateral laughter or the grimace of pain, under the appropriate circumstances, although *cortical* control of the same

[5] *Cf.* P. Bard, A diencephalic mechanism for the expression of rage with special reference to the sympathetic nervous system. *Amer. J. Physiol.*, 1928, 84, 490–516.

[6] H. Head, Studies in neurology, New York, 1920, II, 620.

muscles is bilateral;[2] and (*c*) that temporary impairment of cortical control of lower centers in light anesthesia or permanent impairment by disease releases free and often prolonged weeping or laughing.[2] This last evidence supports the argument for thalamic government of emotional expression only when taken in conjunction with the first two points. It should be clear that the typical modes of emotional behavior are not directly managed by the cortex, as the James-Lange theory postulated, but are directly dependent on patterns of neurone organization in the thalamic region.

Processes in the thalamus are a source of affective experience. This statement is based on clinical evidence, but on evidence which is of prime importance, because it comes from human testimony and because unilateral damage to cortico-thalamic relations renders the experience unilateral, and the witness, therefore, has opportunity for comparing in his own body the normal and the accentuated affective phenomena. Thus when the lesion causes a unilateral release of the thalamus from cortical inhibition, influences which add to sensation an affective element, whether they are aroused by stimulation of peripheral receptors or by central processes (memories), are felt with special intensity on the damaged side. These clinical observations, which have been detailed by Head,[6] have been confirmed by other neurologists.

The reader will note that afferent paths from skeletal muscles and viscera, such as paths 3 and 4, Fig. 1, are not represented in Fig. 2. They are omitted, not because they do not exist, but because their significance in the theory of emotion is in question, and is to be the subject of later discussion.

The Critique by Newman, Perkins and Wheeler

The Definition of Emotion.—First of all the critics repeatedly charge Cannon with inconsistency in using expression as a test of emotion while denying the importance of organic and postural factors. "What then is this illusive thing, emotion?" they ask (*306*).[7] Cannon took no exception to James's

[7] Arabic numbers in parentheses refer to Cannon's paper; italicized numbers refer to the paper by Newman, Perkins and Wheeler.

definition of emotion as a *quale* added to simple perception. The difference lay in the supposed source: James attributed the 'object-emotionally-felt' to the feeling of the bodily changes; Cannon, in italicized words, stated the view that "*The peculiar quality of the emotion is added to simple sensation when the thalamic processes are roused*" (120). He did not declare that awareness of emotion was associated directly with thalamic processes; indeed, in pointing out that "anesthesia in abolishing consciousness while leaving emotional expression (thalamic in origin) undisturbed" (118), he argued against that assumption. The individual patterns of emotional reaction, organized in the thalamus, as mentioned above (see p. 283), are supposed to discharge not only to the periphery but also to the cortex and there to add 'feeling' to sensation, as in the cases of unilateral thalamic lesions (see p. 284).

Newman, Perkins and Wheeler have failed to discriminate between emotional *behavior* and emotional *experience* (*306*). According to the James-Lange theory the two are inseparable —the bodily changes result from impulses from the cortex and report back to the cortex, so that, if the changes occur, the cortex must have received and mediated an affective stimulus or stimulus pattern and would therefore be receptive to reverberations from the periphery. In this view there is no true emotional behavior without emotional experience, and, *vice versa*, there is no felt emotion without peripheral changes. The thalamic theory, on the contrary, admits the possibility of separation—the typical *reactions* have their source in the thalamus, and whether there is an *experience* of emotion or not depends on whether the cortex is present and proper thalamocortical connections are intact. If the points just made are clear the supposed 'inconsistency' charged against Cannon quickly vanishes. He did not state, as charged (*306*), that the 'emotion' disappeared in decorticate cats when the diencephalon was removed, but that the emotional 'activity' subsided (116). There was no inconsistency in his reporting that under the effect of drugs bodily changes of an emotional type occur although the patient is unaware of what is happening—the drugs abolish emotional *experience*, not emotional *behavior*.

Cannon has not used bodily posture in animals 'to denote the presence of emotion' (*307*)—he has admitted ignorance of the 'felt emotion' in lower animals (109), but has pointed out that in spite of "total separation of the central nervous system from the viscera in animals there was no change in their *emotional behavior* (italics in the original)" (108). He has not stated anywhere that "the thalamus is the seat of affectively toned experiences," and yet on the basis of facts mentioned above (p. 284) he has maintained that the thalamus may be the 'source' of such experiences, as retinal changes are the source of visual sensations.

Lack of Specificity of Organic Changes.—Under this heading Newman, Perkins and Wheeler first discuss the point made by Cannon [8] sixteen years ago that the same visceral changes occur in very different intense emotional states and that therefore they cannot be a means of distinguishing emotions having quite different subjective qualities. They admit the point, but declare that not only are the organic changes similar but that the subjective aspects also are much alike. Are they? Do we feel much the same in the elation of joy and in the depression of grief? Does the experience of a towering rage closely resemble abject fear? These are questions which nobody can answer for others. Each person must testify individually. As for myself, I wish to remark that these emotional states are widely different in nature and that I have no difficulty in discriminating between them.

Secondly, they declare that "there is a likelihood that postural factors do play an important part in giving specificity to emotion." What is the evidence for that? They give none whatever. And against the claim is the testimony of the patients studied by Head (see p. 284); unilateral release of the thalamus from cortical control induced in them on the abnormal side an exquisite sensitiveness to affective situations and they reported that *sensations underlying the appreciation of posture are wholly lacking in feeling tone.* As Cannon noted (119) "precisely those afferent impulses from muscles and

[8] W. B. Cannon, Bodily changes in pain, hunger, fear and rage, New York, 1915, p. 275.

joints which James and his supporters have relied upon to provide the extra-visceral part of the felt-emotion are the impulses which lack the necessary quality to serve the purpose." On the other hand emotional feeling may be present although characteristic emotional expression is largely lacking. Bell [9] cites a case of total facial paralysis, without loss of motion in the tongue,—a young girl who "sometimes laughed heartily . . . as if behind a mask; her face being quite immovable and grave whilst the emotion and sound of laughter prevailed." There is no reason for laying aside the direct evidence of persons who because of their misfortune are capable of giving us first-hand information, and taking up instead an assumed 'likelihood' to the contrary, which is stated without any supporting evidence.

As a third point, Newman, Perkins and Wheeler rely upon the 'stimulus-situation' to give specificity to emotion. Since the *response* to the stimulus-situation, normally, is adapted and appropriate, however, it must be organized in the nervous system—and, as emotional response, in the thalamus—before it is expressed outwardly. It is precisely this pattern of neural action, that, according to the thalamic theory, becomes the source of affective feeling, differing as the pattern differs.

Finally, the critics make the statement that the thalamic reaction patterns "are the very postural and organic factors which Cannon denies have anything to do with the emotion," and they inquire why have 'two sets of structures—the thalamus and the body.' Do they suppose that the body 'goes off' into complicated exhibitions of sorrow and joy without any tip from the nervous system? Do they have the idea that the nervous system cannot have plans of action without action? The critics should have a brief experience with spinal anesthesia, and make all the efforts at moving the legs, without effect. As Dunlap [10] has remarked, "Stimulus patterns as units of stimulation and action patterns as units of action require neural patterns as units intermediate between stimulus

[9] C. Bell, The Nervous system of the human body, Washington, 1833, p. 178.

[10] K. Dunlap, Psychological hypotheses concerning the functions of the brain. *Scient. Mo.*, 1930, 31, 112.

and action." The thalamic neural patterns *precede* the postural and organic changes, they are exactly as various as these changes, they can exist without these changes, and according to the theory, by their different conformations they offer a basis for the specificity of the different emotions.

Insensitivity of the Viscera.—Cannon is charged with inconsistency in averring that the viscera are relatively insensitive structures (and therefore incapable of playing an important rôle in emotional experience), and in then declaring that a dose of adrenalin [11] can give rise to what the critics call a 'host of visceral experiences' (*310*). Any dictionary will tell the inquiring reader that the viscera are organs in the body cavities—the stomach, intestines, liver, pancreas, spleen, kidneys, uterus, etc. The critics should present evidence that the active processes going on in these *viscera* play a part in emotional experience. They cite, as the effects of adrenalin, 'epigastric palpitation,' 'arterial throbbing,' 'oppression of the chest,' 'tightness of the throat.' How long since the epigastrium became a viscus, or the chest, or the throat? As evidence clearly indicates (111), we may feel throbbing of blood vessels and also abdominal pains, but that is because parts outside the viscera, which are supplied with sensory nerves, are affected by visceral activities. There is no inconsistency here—or readiness for double dealing, as is intimated (*320*)—and the actual insensitiveness of the viscera stands out prominently as an obstacle to the James-Lange theory. The dicta by Newman, Perkins and Wheeler that "the viscera are very potent and play an important rôle in emotion," and that organic sensitivity is 'without doubt . . . fundamental to emotional experience,' are enunciated without evidence, and wholly beg the question at issue.

[11] Adrenalin disturbs the viscera just as they are disturbed in strong emotion, and yet a dose of adrenalin does not give rise to an emotional feeling (113). Newman, Perkins and Wheeler explain this failure by absence of a specific object—"*There is no goal, nothing to be afraid of, joyful about, or angry at*," they say. It is interesting, in this relation, to compare the critics and James, who remarks (Principles of Psychology, New York, 1890, II, p. 458), "The best proof that the immediate cause of emotion is a physical effect on the nerves is furnished by *those pathological cases in which the emotion is objectless*."

The Visceral Changes Are Too Slow to be a Source of Emotional Feeling.—In discussing this feature of the argument against the James-Lange theory, Cannon reported one observer as finding (in the cat) a *latent period* as low as 0.25 second, and two other observers as finding in the dog and horse *latent periods* of 0.85 and 0.8 second respectively. But besides smooth muscle, viscera are composed of glands; and glandular organs, as examined by such competent physiologists as Langley and Pavlov, have latent periods varying from 2 seconds to 6 minutes. With these latent periods of smooth muscle and glands Cannon compared affective reactions reported by Wells as occurring in 0.8 second, and therefore regarded the visceral changes as being too slow to account for these reactions. Newman, Perkins and Wheeler repeatedly charge Cannon with being unfair, "because," they say, "if he were to take the shortest time in which organic changes take place rather than the longest time, he would have a value in the neighborhood of 0.25 second. This is clearly less than the interval which he gives for reaction times for affective experiences." But is it? The *latent period* is measured to the *beginning* of action. In the case at issue, after the latent period of 0.25 second, the contraction period required five or six seconds [12] and the relaxation period still longer. When does the viscus become the source of afferent impulses—at the end of the latent period when the first slight signs of activity appear or when activity has approached maximal intensity? We know that moderate contractions of smooth muscle do not give rise to sensation and that strong contractions of the same muscle are the occasion of typical pangs. Normal gastric peristalsis, for example, causes no sensory impressions; and even the pang of hunger does not arise until the pea k of the spasm of the gastric musculature has been nearly approached or actually reached.[13] To the latent period, therefore, must be added the time required to develop tension—a period running into seconds, even when a muscle has so short a latent period as 0.25 second. The

[12] C. C. Stewart, Mammalian smooth muscle.—The cat's bladder. *Amer. J. Physiol.*, 1900, 4, 192.

[13] W. B. Cannon and A. L. Washburn, An explanation of hunger, *Amer. J. Physiol.*, 1912, 29, 441.

interval is clearly *more* than the interval for the reaction time for the affective experiences reported by Wells, or even for the subject whose emotional reaction is reported by Newman, Perkins and Wheeler as occurring in 0.9 second. And there is a further consideration. As Cannon explicitly stated (112), to the latent periods of smooth muscle and glands must be added, in the James-Lange theory, the conduction time required for the nerve impulses to travel from the cortex to the periphery and back again (along paths 2 and 3, Fig. 1), before the emotion can be felt. Just how long it takes for nerve impulses to go from the cortex to the stomach, for example, over the extra neurone pathways of the autonomic system (where conduction is slower than in other nerve fibers), and to return to the cortex, is not known. Clearly it is not a negligible period. Newman, Perkins and Wheeler not only do not mention this time, but they do not anywhere justify their exclusion of it—although it is, of course, a main feature of the James-Lange theory which they are defending. Examination of Bayley's study of fear, to which they refer as showing a "delay in the organic changes that is correlated with the delay in the affective aspects of the emotional experience," discloses that Bayley did not report any exact observations on either of the delays. In some experiments performed by the critics themselves—experiments 'in many ways crude,' as they admit, and yielding experiences described by them as 'somewhat vague'—the emotional features were 'not immediate' in appearance and take 'some time.' It would seem that the 'science of psychology' cannot be built on such insecure foundations.

The Rôle of the Thalamus.—Newman, Perkins and Wheeler (*319*) object to Cannon's suggestion that "the peculiar quality of the emotion is added to simple sensation when the thalamic processes are roused," for, they say, the response is not limited to the thalamus alone. That is true, and Cannon has so stated (120)—there is evidence of discharge to the viscera and to skeletal muscles in typical combinations. The critics are so possessed by the belief that these resulting organic changes must be the source of the emotion that they do not understand

how the changes can be without considerable importance. Reasons for belittling their importance were given in Cannon's article,[2] and are not only reviewed in part in the foregoing pages but will be supported by further evidence later (see pp. 293–295). The thalamus, however, not only discharges downwards, it also discharges to the cortex. Complexes of responses in peripheral muscles and viscera are integrated in the nerve centers, not in the periphery, and it is quite as possible for the central integration of emotional responses, organized in the thalamus, to affect by its peculiar pattern the cortex in a peculiar way as for the peripheral changes to do so.

At this point it is pertinent to protest again and especially against ascribing to Cannon the view that the thalamus is the 'seat of the emotions.' Newman, Perkins and Wheeler have repeatedly done that (*320*, *321*, *326*), and they go so far as to declare (*323*) "Cannon infers that if the viscera were the source of emotional experience there should be localization of the affective feelings in the viscera." It would be a satisfaction to know where Cannon has given any, even slight, intimation which would justify the ascription of these ideas to him? They have not been held by him at any time, and he has not been aware of ever giving them any support.

Finally, the critics find difficulty in Cannon's theoretical account of the way in which an emotion-provoking situation might influence the nervous system. The incoming impulses start from R, figure 2; on their way in they may directly excite thalamic processes, or they may go on to the cortex and there arouse conditioned responses which in turn excite thalamic processes—and in either case the peculiar quality of the emotion, as already explained (see p. 285, *supra*), is assumed to be added to simple sensation when the thalamic processes are roused. In the first instance (that of direct excitation of the thalamus) Newman, Perkins and Wheeler suppose that the thalamus takes on a discriminatory function, and tells us to be afraid of a bear, then the impulses go to the cortex and the danger is recognized, then they go to the thalamus to release the thalamic neurones for action, then the thalamic processes

are reported to the cortex and we have the emotion of fear. "The absurdity of this explanation," they state, "is obvious." That may well be. It is not Cannon's explanation. The possibility of direct excitation of the thalamus was recognized by him, because of the fact that certain stimuli—such as loud sounds, for example—can induce emotional reactions even in new-born infants. They are unconditioned stimuli, like acid in the mouth as an unconditioned stimulus of the salivary glands. These stimuli do not involve a discriminatory function in the thalamus. The neural mechanisms there act reflexly and relatively simply in response to certain elemental situations. And in accordance with the thalamic theory the processes thereby aroused would report to the cortex and induce an emotional state. Thus the complicated rigmarole of relations assumed by Newman, Perkins and Wheeler becomes quite as absurd as they describe it.

The critics have difficulty also with the alternative course (that of involving a discriminatory function of the cortex—*e.g.*, the recognition of the bear as dangerous), for, they say, we must then "discard as emotional the abnormal and anæsthetic cases in which the cortical activity is depressed or inhibited. If we do regard these as emotional states, as Cannon does, then how can we get the necessary stimulation by the cortical neurones . . . necessary for the thalamus to function?" Here we have again the failure of the critics to discriminate between emotional *experience* and emotional *behavior*. Emphasizing in italics the fact that he was concerned with '*emotional expression*' Cannon described the behavior of persons, under anesthesia or afflicted with bulbar palsy, who laughed or wept uncontrollably and for long periods. Cannon did not regard these as emotional states, as the critics charge, —indeed, could any words be clearer than these: "The patient may have all the appearances of being convulsed with laughter, yet may not experience any of the feeling which the motions of the face and body indicate" (**117**)? With inhibition or impairment of the cortical control the patterns of the thalamus are free to discharge in laughter or weeping, and, as explained above (p. 285), if thalamo-cortical pathways are

defective or the cortex itself is not functioning, the emotional behavior does not give rise to emotional experience.

Some Claims for the James-Lange Theory Made by Newman, Perkins and Wheeler

In defending the James-Lange theory Newman, Perkins and Wheeler state that visceral, vasomotor and other organic changes are *necessary* conditions for emotional experiences, that organic and kinesthetic experiences are *essential* aspects of emotion, and that the 'feeling tone' of emotion can be resolved into these organic and kinesthetic processes, and consequently is *conditioned by bodily changes* (305).

Since the paper on the thalamic theory of emotion was published [2] I have come upon an article by the well-known neurologist, C. L. Dana,[14] in which he reports a case carefully studied by him with reference to the James-Lange theory. The patient, 'a very intelligent woman of 40,' had broken her neck at the third and fourth cervical level. She was paralyzed in all four limbs and lacked completely cutaneous and deep sensation from the neck down. "She lived for nearly a year, and during that time I saw her showing emotions of grief, joy, displeasure and affection. There was no change in her personality or character. The only skeletal muscles at her command were the cranial, the upper cervical and the diaphragm. As for the vegetative nervous system, she had the vagus, but the vagus has no active (low-level) sensory fibres except the laryngeal. The parasympathetic system in this patient was able to function, but the sympathetic proper was absolutely eliminated from subconsciousness and consciousness. It is difficult to understand, on the peripheral theory, why there should have been no change in her emotionally, with the skeletal system practically eliminated and the sympathetic entirely so."

Thereupon Dana cites cases of tabes with wholly atonic, anesthetic and greatly wasted skeletal muscles, yet with normal emotions; cases of progressive muscular atrophy with

[14] C. L. Dana, The anatomic seat of the emotions, a discussion of the James-Lange Theory, *Arch. Neur. & Psychiat.*, 1921, 6, 634.

complete bodily immobility and paralysis, cases of terminal arthritis deformans with absolute bodily rigidity, cases of paralysis agitans with only automatic muscular movements and those which are under autonomic control—all with emotional reactions present and natural. As a consequence of these observations Dana concludes, "I am led to the conclusion that emotion is centrally located and results from the action and interraction of the cortex and thalamus . . . . The centers that control the activities of the vegetative nervous system are mainly in the brain stem. These centers are first appealed to when the animal perceives something calling for instant action in defense, offense or active desire. They, on the other hand, stir up the muscles, viscera and glands, but they also appeal through the thalamus to the cortex and arouse the emotions appropriate to the object recognized or idea that has been aroused." It is evident that Dana was led by his observations and thinking to the same conclusion that Cannon arrived at later and quite independently.

Cases similar to those cited by Dana have been described by the British neurologist, Wilson.[15] He reports cases of pathological laughing and crying in which the outward expression by no means always corresponds to the patient's real feelings. "More than one patient," he writes, "has protested against the laughter or tears being taken as the index of his actual affective state. The conclusion is unmistakable, that the bodily reverberation, as James calls it, is not *per se* the emotion. . . . With all the outward appearances of mirth and hilariousness, and with concomitant activity of visceral mechanisms, the individual may not only not feel happy, but his state of mind may be in patent conflict with the apparent emotion." And again in cases in which free movement of facial musculature was impeded by disease and in which there was inquiry into the patient's feeling under the influence of appropriate stimuli: "The patient can readily feel and be acutely conscious of experiencing a particular emotional state such as that associated with hilarity and joy in spite of minimal expression in the face. . . . A facial

[15] S. A. K. Wilson, Modern problems in neurology, New York, 1929, p. 275.

diplegic, as one has often seen, may preserve a mask-like countenance and yet be moved by 'inward' laughter." In one such case the patient "termed it his greatest misfortune that he was forced to be joyful or sad without making any demonstration of his feelings to his fellow creatures." And Wilson confesses, "From the standpoint of the clinician, therefore, I find myself in accord with the physiologist when he declares that 'the reverberation from the trunk, limbs and viscera counts for relatively little . . . as compared with the cerebral reverberation to which is adjunct the psychical component of the emotional reaction.'"

In 1884, James [16] made an appeal to asylum physicians and neurologists. He admitted that if the hypothesis which he suggested "is ever to be definitely confirmed or disproved it seems as if it must be by them, for they alone have the data in their hands." Eminent and experienced specialists in nervous disorders, who have studied carefully their cases with reference to the James-Lange hypothesis, deny its validity. The claim of Newman, Perkins and Wheeler, that organic and kinesthetic processes are 'necessary' for emotional experiences, are 'essential aspects' of such experiences, in short 'condition' such experiences, receives no support from human witnesses, who, because of peculiar damage to the nervous system, are able to give us expert testimony. And the clinical observers, like the physiological experimenters, have been forced by the facts to turn away from the idea that emotions have a peripheral source. The thalamic theory offers an alternative view, and, as Cannon explained in his account of that theory, it appears to be in accord with the facts now known.

[16] W. James, What is an emotion? *Mind*, 1884, 9, p. 188.

[MS. received March 9, 1931]

THE PSYCHOPATHOLOGY OF GEORGE FOX, THE FOUNDER OF QUAKERISM

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One of our modern writers on mental disorders asserts that "a study of the life of the saints is much more of an excursion into psychiatry than is a study of the life of the great sinners."[1] Indeed, it is not uncommon to find men of extraordinary religious insight the victims of pathological tendencies.[2] Concerning this very interesting phenomenon William James makes the pertinent observation that "religious geniuses have often shown symptoms of nervous instability. Even more perhaps than other kinds of genius, religious leaders have been subject to psychical visitations. Invariably they have been creatures of exalted emotional sensibility." [3]

It has long been recognized that George Fox (1624–1691), the founder of the Quaker religion, was a pathological subject.[4] About all that Lord Macaulay could say concerning him was that he was a fool and a fanatic, though Macaulay probably had a prejudice against the Quakers in general, and against George Fox in particular. He describes Fox, in his characteristically picturesque style, as a man with "an in-

[1] A. Myerson, The psychology of mental disorders, New York, The Macmillan Company, 1928, p. 35.

[2] For a brief discussion of the prevalence of instability in a few religious leaders the reader might peruse, with profit, an article by P. A. Witty, and H. C. Lehman, Religious leadership and stability, PSYCHOL. REV., 1929, 36, pp. 56–82. For a more complete study of a single religious psychopath, however, one might consult an article by Josiah Royce, entitled, The case of John Bunyan, PSYCHOL. REV., 1894, 1, pp. 22–33, 134–151, 230–240.

[3] W. James, The varieties of religious experience, Thirty-sixth Impression, New York, Longmans Green and Co., 1928, p. 6.

[4] It is no mean judgment that we pass upon George Fox when we class him as a psychopath. Psychopathic dispositions should be judged by the pragmatic test. "By their fruits ye shall know them," insists William James, "not by their roots." The fruits are often good, for such dispositions give tremendous force to the pathological subject.

tellect in the most unhappy of all states, that is to say, too much disordered for liberty, and not sufficiently disordered for Bedlam."[5] Many of Fox's greatest admirers have admitted that he was abnormal. There was in him a well-marked mixture of psychopathic traits, for he was one, as Rufus Jones says, 'in whom the normal and the abnormal kept house together.'[6] William James further corroborates these judgments by suggesting that "from the point of view of his nervous constitution, Fox was a psychopath or *détraqué* of the deepest dye."[7] Fox's autobiography[8] is replete with statements that quite clearly reveal his unstable psychic constitution, and many of these entries appear to be very similar to the evidences of instability that one often discovers in the autobiographies of many other mystics and religious leaders.[9]

Fox is an outstanding example of a pathological subject who in small measure learned the lesson of self-control. To be sure, the lesson was learned very slowly and after many mistakes had been made; but to achieve proper balance, to attain commanding poise, is for some the work of a whole lifetime. If he had not learned something of the art of self-control, much of his energy would have been dissipated and his name would have been numbered among the great army of deluded religious fanatics of the past. As it was, however, he was partly able to conserve for good use a considerable portion of his energy, and to direct the dynamic power of his emotions

[5] T. B. Macaulay, The history of England from the accession of James the Second, Boston and New York, Houghton Mifflin Co., 1810, IV, p. 136.

[6] From a tercentenary collection of studies, entitled, New appreciations of George Fox, London, The Swarthmore Press, 1925, p. 68.

[7] *Op. cit.*, p. 7.

[8] In this investigation of George Fox, the writer has found it necessary to make use of several different editions of Fox's *Journal*. Especially has the 1911 Cambridge edition, by Norman Penney, proved to be of very great worth. Previous editions are not so valuable to the psychologist because oftentimes they omit the pathological characteristics of George Fox. For general use, however, the author has found Rufus M. Jones' edition, George Fox; An Autobiography, a condensed form of the *Journal* with its spelling modernized, much more satisfactory than other volumes. All references from the *Journal*, therefore, are taken from this edition.

[9] Professor Pratt has an excellent, though brief, discussion of the meanings of 'normal' and 'abnormal' as applied to mysticism.—J. B. Pratt, The religious consciousness, New York, The Macmillan Company, 1924, pp. 465–466.

for a noble work in the world. This partially unifying process of the inner self, this story of how Fox little by little became more of a master over his personality, is as dramatic and as fascinating as the story of how he gradually became master of a new religious group; but we must turn back to get a glimpse of the instability of the man himself.

It is, of course, impossible to make a thoroughly accurate investigation and diagnosis of Fox; one can only point out a probable analysis. From all the materials available one cannot prove that there was any congenital weakness, though Fox was quite eccentric from his earliest youth. Nor can it be shown that he was definitely psychotic. He was never mad. He was not a lunatic, though antagonistic contemporaries believed him to be, just as Festus looked upon the apostle Paul as being strangely 'beside himself.' Rather, he was a psychoneurotic, and in studying Fox we are dealing with a constant state of conflict and a considerable degree of repression. There can be little doubt about his condition; he presents a typical picture of neurasthenia. He was hyperesthesic in the extreme—so much so that he was delicately suspended between health and nervous instability. At times he manifested symptoms that might be readily diagnosed by many students of abnormal behavior as a mild manic-depressive temperament. His discordant personality exhibited several striking neurotic symptoms,—intermittent doubts, religious obsessions, impelling dreads, chronic anxieties, hysterical seizures, *et cetera*. He was frustrated every way he turned, as is usually the case with neurotics.

George Fox was a creature of exalted emotional sensibility. He had a powerful physique but he was so very hyper-sensitive that he was easily subject to psychic disturbances. He had highly developed perceptive powers and remarkable keenness of discernment. He seemed to be capable of experiencing stimulations not consciously registered in the nervous mechanisms of average men. Dr. Knight, in her most interesting, though fantastic, treatment of Fox's mysticism from the psychological point of view, thinks that the acuteness and delicacy of his senses formed one of the primary

sources of his mystical insight.[10] Indeed, this may be true.

In order to understand the psychic make-up of George Fox, however, one must first consider the nature of the times in which he lived. The century which preceded the birth of Fox (1624) witnessed profound changes in the religious life of the people of England. In the course of this breath-taking hundred years the English nation had seen its king rend the age-old bonds which united England to Rome and organize a national church with himself as head. Nonetheless, the new church still clung to many of the attributes of Catholicism and an increasing group of malcontents became all the more restless as they perceived that the Romish practices against which they carped were not being removed. Among these disgruntled extremists the feeling developed that it was their mission to purge Anglicanism of its 'popish' characteristics and to purify it of everything that was not strictly Calvinistic. Hence the name Puritan, which, by the time of Fox, had become of political as well as religious significance.

The general state of seventeenth-century England was quite chaotic, for religious fanaticism, horrible persecution, and untempered controversy prevailed. It was the religious and social environment that had more influence upon Fox than the political. The nemesis of Protestantism was beginning to appear, in that within the ranks of the Puritan opposition there were numerous individuals who refused to step with the majority. Various dissenting sects throughout the length and breadth of the land were boldly announcing their principles, and religious controversy was the order of the day. Numerous were the debates between Calvinists and Arminians, and hotly contested were their forensic encounters. The country was full of various dissenting sects,—Brownists, Erastians, The Family of Love, Antinomians, Ranters, Seekers, and a host of others. A new religious consciousness was in the making, while governmental and social forms were likewise in the process of evolution. Everything was in flux; nothing was quite stable. It was, therefore, very difficult for

[10] R. Knight, The founder of Quakerism; A psychological study of the mysticism of George Fox, London, The Swarthmore Press, 1922, p. 42.

a man of such emotional delicacy and such acute sensitiveness as George Fox to live in an unstable social order without becoming a little unsteady himself.

Fox was eccentric as a youth, but it would seem that he was not as unstable during these early years as he was merely unusual and exceptional. During this period one notes the peculiar qualities of this lad who 'had a gravity and stayedness of mind and spirit not usual in children,' [11] but one fails to note the psychopathic tendencies that were so characteristic of him as he approached manhood. True enough, there are evidences of chronic doubts and anxieties; but there are few, if any, examples of religious frenzy. Perhaps if he had been brought up in a different environment, psychical disturbances would never have made their appearance. As a boy Fox was not especially morbid, though he was very sombre, pensive, and introspective. He was so serious-minded that his contemporaries looked upon him as being very erratic, and his friends were very solicitous as to his well-being. Nevertheless, eccentricity does not necessarily indicate abnormality, and it would not appear that genuine psychopathic symptoms were exhibited in Fox until he was about twenty years of age.

The beginning of Fox's religious distress, which gradually contributed to his instability, is well told by him in the following episode:

> When I came towards nineteen years of age, being upon business at a fair, one of my cousins, whose name was Bradford, having another professor [12] with him, came and asked me to drink part of a jug of beer with them. I, being thirsty, went in with them, for I loved any who had a sense of good, or that sought after the Lord.
>
> When we had drunk a glass apiece, they began to drink healths, and called for more drink, agreeing together that he that would not drink should pay all. I was grieved that any who made profession of religion should offer to do so. They grieved me very much, having never had such a thing put to me before by any sort of people. Wherefore I rose up, and putting my hand in my pocket, took out a grote, and laid it upon the table before them, saying, "If it be so, I will leave you."

[11] Journal, p. 66.

[12] By the term 'professor' Fox has reference to a nominal Christian, or, as we would say today, a church member.

So I went away; and when I had done my business returned home; but did not go to bed that night, nor could I sleep, but sometimes walked up and down, and sometimes prayed and cried unto the Lord, who said unto me: "Thou seest how young people go together into vanity, and old people into the earth; thou must forsake all, young and old, keep out of all, and be as a stranger unto all." [13]

This episode marked the beginning of Fox's despair. He immediately left his relations and wandered from place to place in search of some spiritual consolation. He says:

I was about twenty years of age when these exercises came upon me; and some years I continued in that condition, in great trouble; and fain I would have put it from me. I went to many a priest [14] to look for comfort, but found no comfort from them.[15]

It was on one of his visits to a minister by the name of Macham that an attempt was made to bleed him, but not one drop of blood could be drawn either from his arms or from his head. This is the first genuine psychopathic symptom that one discovers in Fox.

From early childhood onward Fox was strongly inclined toward exhibiting characteristics of the introvert, though as he grew older his aloofness gradually gave way to gregariousness. The following few entries from the Journal point to his liking for solitude during his earlier years:

Sometimes I kept myself retired to my chamber, and often walked solitary in the Chase to wait upon the Lord. (P. 69.)

But my relations were much troubled that I would not go with them to hear the priest; for I would go out into the orchard or the fields, with my Bible, by myself. (P. 75.)

I fasted much, walked abroad in solitary places many days, and often took my Bible, and sat in hollow trees and lonesome places till night came on; and frequently in the night walked mournfully about by myself. . . .

During all this time I was never joined in profession of religion

[13] Journal, p. 68.

[14] When Fox uses the word 'priest' he usually refers to any minister who received a salary for his preaching.

[15] Journal, p. 70.

with any, but gave up myself to the Lord, having forsaken all evil company, taken leave of father and mother, and all other relations, and travelled up and down as a stranger in the earth, which way the Lord inclined my heart; taking a chamber to myself in the town where I came, and tarrying, sometimes more, sometimes less, in a place. . . . For this reason I kept much as a stranger, seeking heavenly wisdom and getting knowledge from the Lord, and was brought off from outward things to rely on the Lord alone. (Pp. 79–80.)

I was afraid of all company. . . . I had not fellowship with any people, priest or professors, or any sort of separated people, but with Christ, who hath the key, and opened the door of Light and Life unto me. (P. 83.)

Fox was dominated by a religious complex which developed in early years and which persisted through his entire life. It is a comparatively easy matter to trace the evolution of this complex. He had been brought up in a very Puritanical atmosphere, where all life was permeated by religion.[16] He lived an extraordinarily contemplative and serious existence. So saturated did he become with religious ideas that one does not wonder that a religious complex developed. It would appear to be a psychological fact, so Tansley concludes, "that no mind can occupy itself in the same channels for a long period without developing a complex, however weakly organized, and a characteristic affect attached to the complex." [17] Religion had become for this pensive, introspective individual 'the whole of life,' and to the religious stimulus there was the 'all-or-none' response—just as it is found in most of the religious geniuses. This is characteristic of those who are dominated by an impelling complex. Giving themselves over to it completely, they are capable of manifesting extraordinary power and energy.

[16] In this austere environment, largely Calvinistic, he was taught to fear God, and 'fear became a kind of reverence for him.' All play was considered evil, hence he repressed the impulse of play. The things of the world were considered 'of the earth earthy,' thus he revolted from all conventions. Matters of sex were considered strictly taboo, hence he repressed all sexual thoughts and desires.

[17] A. G. Tansley, The new psychology and its relations to life, London, George Allen and Unwin Ltd., 1924, p. 67.

Accompanying this complex, with its obsessions, anxieties, *et cetera*, was an inner conflict—a parallelistic phenomenon that one often discovers in religious geniuses. Fox experienced in his adolescence that inward turmoil which is so characteristic of many of the world's spiritual leaders. His early life was filled with temptation, anxiety, and despair. He writes in his Journal:

> During the time I was at Barnet a strong temptation to despair came upon me. I then saw how Christ was tempted, and mighty troubles I was in. . . . I wondered why these things should come to me. I looked upon myself, and said, "Was I ever so before?"
>
> So I was brought to call to mind all my time that I had spent, and to consider whether I had wronged any; but temptations grew more and more, and I was tempted almost to despair; and when Satan could not effect his design upon me that way, he laid snares and baits to draw me to commit sin, whereof he might take advantage to bring me to despair. (P. 69.)
>
> From Barnet I went to London, where I took a lodging, and was under great misery and trouble there. . . . (P. 70.)
>
> After some time I went into my own country again, and continued about a year, in great sorrow and trouble, and walked many nights by myself. (P. 71.)
>
> Now, though I had great openings, yet great trouble and temptation came many times upon me; so that when it was day I wished for night, and when it was night I wished for day. . . . (Pp. 77–78.)
>
> When I myself was in the deep, shut up under all, I could not believe that I should ever overcome; my troubles, my sorrows, and my temptations were so great that I thought many times I should have despaired, I was so tempted. (P. 83.)
>
> Thus, in the deepest miseries, and in the greatest sorrows and temptations, that many times beset me, the Lord in His mercy did keep me. (P. 84.)
>
> Then came the tempter and set upon me again, charging me that I had sinned against the Holy Ghost; but I could not tell in what. (P. 89.)
>
> One morning, as I was sitting by the fire, a great cloud came over me, and a temptation beset me; and I sat still. (P. 94.)

This conflict did not result wholly as a pathological anxiety

regarding his own wickedness; the inward disturbance was not a pronounced case of despondency or despair because of a fear of being doomed to eternal torment. The *Sturm und Drang* did not follow a consciousness of sin or wrongdoing, as was the case of John Bunyan, the Bedford pastor. Fox was much less an introvert than Bunyan. As a matter of fact, Fox was unusually innocent and pure as a youth. He says of himself:

> When I came to eleven years of age I knew pureness and righteousness; for while a child I was taught how to walk to be kept pure.[18]

As he grew up, his relatives planned that he should enter the ministry, but they were persuaded to the contrary. Instead, he was apprenticed to a shoemaker, and concerning his life during these years, he writes:

> I never wronged man or woman in all that time; for the Lord's power was with me and over me, to preserve me. While I was in that service I used in my dealings the word Verily, and it was a common saying among those who knew me, "If George says verily, there is no altering him." When boys and rude persons would laugh at me, I let them alone and went my way; but people had generally a love to me for my innocency and honesty.[19]

Fox's manner of living was certainly not responsible for his adolescent turmoil. In quite a contrary fashion, his conflict was between the 'inner' and the 'outer'; there was a great chasm which seemed to exist between his inner self—his convictions and promptings—and the outer world in which he lived and moved. He was far more sensitive than the average man to the evils of the world, and was filled with alarm and dreadful apprehension upon his discovery that existing religion was without spiritual power and insight. The following few scattered excerpts from the Journal indicate the nature of his sensitiveness to external religious conditions:

> As I traveled through the country, professors took notice of me, and sought to be acquainted with me; but I was afraid of them, for I was sensible they did not possess what they professed. (P. 69.)

[18] Journal, p. 66.
[19] *Ibid.*, p. 67.

From Barnet I went to London, where I took a lodging, and was under great misery and trouble there; for I looked upon the great professors of the city of London, and saw all was dark and under the chain of darkness. (P. 70.)

But my relations were much troubled that I would not go with them to hear the priest. . . . I saw that to be a true believer was another thing than they looked upon it to be. . . . So neither them, nor any of the dissenting people, could I join with; but was as a stranger to all, relying wholly upon the Lord Jesus Christ. (Pp. 75-76.)

But as I had forsaken the priests, so I left the separate preachers also, and those esteemed the most experienced people; for I saw there was none among them all that could speak to my condition. (P. 82.)

Fox was so shocked by the patent discrepancy between the religion of the Gospel on the one hand and the religion of the churches on the other, that he was thrown into serious mental conflict, his emotional poise was unbalanced, and he was occasionally led into all sorts of pathological behavior. This period of stress and strain kept him constantly on tension. "I was," he says, "a man of sorrows in the time of the first workings of the Lord in me." This gulf between the 'inner' and the 'outer' could not be bridged. The conflict was overwhelming and much more than he could endure during his years of mental turmoil.

So long as this dominating complex with its accompanying conflict could be kept controlled, Fox appeared mentally and emotionally balanced, but it could not be kept submerged all the time. It was ever in readiness for an eruption and its volcanic fires smouldered so near the surface that the slightest stimulus might cause it to break forth with terrific violence. Whenever this complex became master of his mind he fell into a state of instability. It sometimes expressed itself in the form of psychopathic behavior, producing trance, loss of sight and hearing, and similar symptoms of hysteria. It did not always, however, create such a profound disturbance of the personality, for it was sometimes directed into a substitute

reaction of denunciation.[20] This substitute reaction provided an outlet for releasing pent-up psychophysical energy; by it he could direct his behavior reactions in such a way that his energy might be turned outward on others rather than inward upon himself.

Any stimulus associated with Fox's complex or conflict was effective in arousing the complex to action. For instance, the 'steeple-house' (a name for any church edifice of those religious groups, toward which Fox had such an aversion) was sufficient stimulus for stirring up the complex. The church building, in other words, was associated with his complex just as some particular garment would be associated with the person who usually wore it. It took on symbolic significance; it became a sign for the thing signified. Evidences of the potency of the 'steeple-house' stimulus in exciting the complex to action are well brought out in the following few instances from the Journal:

> Now as I went towards Nottingham, on a First-day, in the morning, going with Friends to a meeting there, when I came to the top of a hill in sight of the town, I espied the great steeple-house. And the Lord said unto me, "Thou must go cry against yonder great idol, and against the worshippers therein." (P. 109.)
>
> As we travelled along the country I espied a steeple-house, and it struck at my life. (P. 314.)

In like manner, the church bell was just as effective in arousing the complex. Thus he writes:

> The earthly spirit of the priests wounded my life; and when I heard the bell toll to call people together to the steeple-house, it struck at my life; for it was just like a market-bell, to gather people together, that the priest might set forth his ware for sale.[21]

The sound of the bells actually became unpleasant to him, though he did not recognize the real reason for such an aver-

[20] The author now has in press an article in *J. Relig.*, (University of Chicago Press) entitled, The Denunciations of George Fox Viewed Psychologically. This paper attempts to show that Fox's denunciations can be explained psychologically on the basis of the following causal factors: (1) a well developed superiority complex, (2) a compensation for physical non-resistance, (3) pathology, and (4) motor-mindedness.

[21] Journal, pp. 107–108.

sion. Bernard Hart cites a very similar case mentioned by Jung.[22] Here again, therefore, we discover in this symbolism an example of the indirect expression of his complex. When some stimulus, either objective or ideational, caused an uprush of the complex into consciousness, he became extremely emotionalized and bodily changes occasionally resulted. He was often thrown into an emotional state of rage and his complex became for him a veritable source of energy.

One of the most interesting things to study in the life of George Fox is his 'openings.'[23] A careful examination of these phenomena points definitely to his abnormal psychic constitution. The 'openings' that came to Fox have much in common with those which Jacob Boehme and Loyola experienced, though the 'openings' of Loyola were not so frequent.

> About the beginning of the year 1646, as I was going to Coventry, . . . the Lord opened to me that if all were believers, then they were all born of God, and passed from death to life; and that none were true believers but such; and, though others said they were believers, yet they were not. (P. 74.)
>
> At another time, as I was walking in a field on a First-day morning, the Lord opened unto me that being bred at Oxford or Cambridge was not enough to fit and qualify men to be ministers of Christ; and I wondered at it, because it was the common belief of the people. (Pp. 74–75.)

[22] B. Hart, The psychology of insanity, Cambridge, At the University Press, 1921, p. 73.

Another case of this same sort of symbolism is cited by Max A. Bahr, superintendent of the Central Indiana Hospital for the Insane. In a newspaper article the doctor tells of a patient who at one time was a prominent spinster in a small town. She fell in love with a minister who was married and was the father of two children. The minister was wholly unconscious of the woman's affection. Because her failure in her attempt to win him would be obvious to her friends, should the fact be known, the woman could not manifest any outward show of hatred for the minister. Soon she was found venting her wrath on the bells of the minister's church. She complained to the town board that the bells were unpleasant in sound and that they disturbed her peace. She asked that they be removed, and when her request was refused, she became mentally unstable.—Inferiority Complex Responsible For Numerous Cases of Insanity, *Indianapolis* (Sunday) *Star*, Nov. 25, 1928, Section I, p. 16.

[23] When Fox uses the word 'opened' he has reference to the same thing that the mystics speak of, namely, a direct revelation that comes to the recipient with absolute certainty as to its truth-quality.

At another time it was opened in me that God, who made the world, did not dwell in temples made with hands. This at first seemed a strange word. . . . (P. 76.)

I had also great openings concerning the things written in the Revelations. . . . (P. 77.)

When I had openings they answered one another and answered the Scriptures; for I had great openings of the Scriptures. . . . (P. 78.)

When all my hopes in them and in all men were gone, so that I had nothing outwardly to help me, nor could I tell what to do, then, oh, then, I heard a voice which said, "There is one, even Christ Jesus, that can speak to thy condition." . . . (P. 82.)

The Lord opened me, that I saw all through these troubles and temptations. (P. 84.)

While I was there the Lord opened to me three things relating to those three great professions in the world,—law, physic, and divinity (so called). (P. 98.)

On a certain time, as I was walking in the fields, the Lord said unto me, "Thy name is written in the Lamb's book of life, which was before the foundation of the world." . . . (P. 102.)

Then was I commanded by the Lord to pull off my shoes. . . . I walked on about a mile, and as soon as I was got within the city, the Word of the Lord came to me again, saying, "Cry, Woe to the bloody city of Lichfield!" (P. 132.)

To the student of psychology a reasonable explanation can be offered for these revelations that appeared to surge up into consciousness. There seems to be no need for a supernatural etiology. We need not go so far as to deny the validity of the supernatural; we simply affirm that the phenomenon can be reasonably explained without such an hypothesis. Fox was a victim of automatisms, both sensory and motor. The 'openings,' moreover, may be explained either as being rehearsals of experience through ordinary thought association and reproduction, or as being unconscious thought integrations, which were thrown into consciousness and experienced as though they were wholly new. The latter explanation is probably more acceptable.

Fox longed for something that could give him spiritual consolation and comfort, and it was finally 'opened' to him that

there was one, Christ Jesus, who could satisfy this longing. His experience with many ministers had led him to the conclusion that an education was not essential for them; hence, in harmony with his own feeling in the matter, it was 'opened' to him 'that being bred at Oxford or Cambridge was not enough to fit and qualify men to be ministers of Christ.' This 'opening,' moreover, in perfect accordance with his own liking, 'struck at priest Stephen's ministry.' He gradually had come to have an aversion to 'steeple-houses'; hence it was 'opened' to him that "God, who made the world, did not dwell in temples made with hands." He was well acquainted with the teachings of the Scriptures; thus he had great 'openings' 'concerning the things written in the Revelations.' He wished to rid himself of his temptations; hence through an 'opening' the Lord showed him 'all through these troubles and temptations.'

The 'openings' may then be thought of as explosions from the subliminal region following a period of unconscious incubation, and, as such, they uncover the wish-content of Fox's mind. Strong feelings and desires, not having been allowed to realize fulfillment, could not be completely repressed from the mind, but would, on occasions, suddenly burst into consciousness. Here they became detached from the self and were objectified as of divine origin. Usually the 'opening' came in either auditory or visual imagery. The auditory formulation of inner revelation is quite common among the mystics; the voice of God is heard—just as Fox often experienced an imaged sound of the 'voice of the Lord.' [24]

When Fox speaks of a voice communicating to him, we are not certain that he actually *heard* a voice; he may simply refer

[24] The content of these 'openings' was of different types. Usually they came as an impulse to action, calling out some motor response. Kinaesthetic strains played a very important rôle in giving immediacy to his religious mysticism. He felt that the Lord *led* him or that he was being *moved* by the Divine Spirit. These motor strains were objectified and felt as actually real. At other times the 'openings' were of the consoling type, and occasionally they were of the pure discernment type, by which he was enabled to discern evil in some one or to expose false teachers. Most, if not all, of these 'openings' were not new truths, but told of something that had previously been announced by other religious groups or by other religious teachers. Many of them set forth truths that could have been found easily in the Scriptures or from conversing with contemporary religious leaders.

to his having experienced some vague motor speech imagery. He speaks as if he really had auditions, but the fact of his actually having them is not so certain.[25] If he did experience auditions they were of the nature of auditory hallucinations.[26] Regardless of whether these 'openings' were actual hallucinations or simply vague visual and auditory types of imagery, Fox nonetheless considered them as real, as being projected upon him from a divine source; the revelations were objectified by him as of external, hence divine origin.

Another evidence of Fox's instability is to be found in the symptomatology of hysteria. His emotional life was so delicately poised that he was subject to sudden physical changes and transformations. Visceral changes, resulting from strong emotional excitation can be detected from certain notes in his Journal. His circulatory system so reacted on one occasion that the blood was driven back from the periphery of his body, making it impossible for him to be bled.[27] He writes concerning this experience:

> After this I went to another, one Macham, a priest in high account. He would needs give me some physic, and I was to have been let blood; but they could not get one drop of blood from me, either in arms or head (though they endeavoured to do so), my body being, as it were, dried up with sorrows, griefs and troubles, which were so great upon me that I could have wished I had never been born, or that I had been born blind, that I might never have seen wickedness or vanity; and deaf, that I might never have heard vain and wicked words, or the Lord's name blasphemed.[28]

[25] Professor Leuba believes that the mystic does not have any revelation at all—that the experience is wholly illusory. Professor Pratt, on the other hand, says that, while various explanations of the mystic's conviction of insight go a long way, it cannot be shown that his sense of revelation is *entirely* illusory—J. B. Pratt, *op. cit.*, p. 410.

[26] Concerning the auditory 'openings' Josiah Royce remarks that "one may doubt whether these voices often had the character of true auditory hallucinations. They appear in general, more like those interior voices whose mental material consists rather of motor speech imagery than of words vividly heard."—J. Royce, George Fox as a mystic, *The Harvard Theological Review*, January, 1913, p. 49.

[27] There are no grounds for supposing that there was not a normal quantity of blood in him. To the student of psychology this is an indication of hysteria, in which the blood was being driven back from the periphery of the body. Professor Cannon, *et al.*, have shown how such changes may occur as the result of strong emotional excitation.

[28] Journal, p. 73.

On another occasion Fox went into a fourteen-day trance—an abnormal state that was brought on by the death of a friend. He experienced a decided subliminal transformation, which he describes as follows:

> When this man was buried a great work of the Lord fell upon me, to the admiration of many, who thought I had been dead, and many came to see me for about fourteen days. I was very much altered in countenance and person, as if my body had been new moulded and changed.[29]

Fox suffered a recurrence of hysteria late in life near Rochester, where he became quite ill. Arriving at Gravesend, he could hardly eat or sleep, and with great uneasiness he rode to the home of a friend at Stratford. He says: "Here I lay exceedingly weak, and at last lost both hearing and sight." [30]

Such a physical change as this was nothing more than a result of psychical disturbance. Fox was easily thrown into an hysterical state, from which condition it usually took some time for him to recover completely. He was a creature of such exalted emotional sensitivity that he was constantly in danger of having his whole physical mechanism cast into some markedly pathological type of behavior. On a few occasions he tells us that he 'was struck even blind' when stirred by some deep emotion.[31] For instance, he says:

> At a certain time, when I was at Mansfield, there was a sitting of the justices about hiring of servants; and it was upon me from the Lord to go and speak to the justices, that they should not oppress the servants in their wages. So I walked towards the inn where they sat; but finding a company of fiddlers there, I did not go in, but thought to come in the morning, when I might have a more serious opportunity to discourse with them.
>
> But when I came in the morning, they were gone, and I was struck even blind, that I could not see. I inquired of the innkeeper

[29] *Ibid.*, p. 87.

[30] Journal, p. 477.

[31] The psychologist is well acquainted with blindness resulting from autosuggestion in certain types of nervous invalids. He is also familiar with temporary blindness resulting from a centering of the blood supply in the brain centers under strong emotional excitability.

where the justices were to sit that day; and he told me, at a town eight miles off. My sight began to come to me again; and I went and ran thitherward as fast as I could.[32]

The anesthesias comprise an important group of hysterical symptoms. In the case of Fox they seem to be limited mainly to the visual and auditory sensory modes, although we may suppose that the tactual mode was probably likewise involved. It cannot be determined definitely from the limited material available whether the visual anesthesia involved simply a restricted visual field, whether it included one or both eyes, or whether it resulted in complete hysterical blindness. Nevertheless, when all the symptoms are taken together—emotional instability, loss of sight and hearing, stuporous and trance states, ego-centricity, depression and exaltation, *et cetera*—one does not doubt the fact that Fox was the victim of occasional hysterical seizures.

There is another phenomenon which the student of abnormal behavior would find fascinating. Occasionally Fox had what now would be classed as telephathic experiences, which influenced him in a decidedly emotional fashion. In at least one place Fox tells us that he had a sense of things taking place at a distance (telesthesia), and especially did he seem to have occasionally a peculiar insight into the needs of Quakers, from whom he was spatially separated.[33] He seemed to have a telepathic knowledge of the persecution of his brethren in New England. He says:

> When those were put to death I was in prison at Lancaster, and had a perfect sense of their sufferings as though it had been myself, and as though the halter had been put about my own neck, though we had not at that time heard of it.[34]

Nothing can be said about these few cases where there seemed to be communication of thought from one mind to

[32] Journal, pp. 95–96.

[33] One form of telesthesia is the sensing of conditions which are prevented by distance from arousing sensation and perception in the normal manner. Whether or not any portion of the sensory or perceptive apparatus is made use of in this form has not been definitely determined.

[34] Journal, pp. 373–374.

another by other than the usual modes of sensory stimulation. No analysis can be made, because they took place spontaneously and apart from any possibility of a systematic study of them. There are possible errors of report and errors of illusion, and there can be no good evidence for telepathic phenomena until every source of error has been eliminated.[35] Possibly we should dismiss Fox's telepathic experiences on the ground that he was too much concerned in reporting what seemed to be supernatural. He probably is guilty of the common error of leaving us an account of a very few of the positive instances of telepathic insight and neglecting to mention the large number of negative instances.

Fox was subject, likewise, to disturbing visions, in which some desperate creature was sometimes foiled in his attempt to destroy him, and it would appear that such hideous experiences were due to repressed fear, dread, and anxiety. He briefly describes one of these visions as follows:

> But, being at Brandon, there appeared to me in a vision a very ugly-visaged man, of a black and dark look. My spirit struck at him in the power of God, and it seemed to me that I rode over him with my horse, and my horse set his foot on the side of his face.[36]

On one occasion he tells us of a very lucid vision of the New Jerusalem, which, coming as it did during a state of spiritual suffering and anguish, points to a repressed desire working as a satisfying means of escape from reality. As a matter of fact, the compensation mechanism played a very important rôle in Fox's life in many connections. There is very good evidence for showing that his frequent denunciations were compensations for consciousness of inferiority and failure.

Furthermore, Fox often compensated for his philosophy of physical non-resistance by experiencing satisfaction from vicarious vengeance. Any punishment of his opponents, which came from other than his own hands, quite well served

[35] In an exhaustive experimental study of the possibility of telepathic communication, Professor Coover discovered that the frequency of success was no higher than should occur by a chance mathematical calculation.—J. E. Coover, Experiments in psychical research, Stanford University Press, p. 39.

[36] Journal, p. 465.

the purpose of balancing matters, and he usually saw—naïvely to be sure—the hand of the Lord back of the chastisement of those who harassed him. Thus he writes:

> Indeed, I could not but take notice how the hand of the Lord turned against the persecutors who had been the cause of my imprisonment, or had been abusive or cruel to me in it. The officer that fetched me to Holker-Hall wasted his estate, and soon after fled into Ireland. Most of the justices that were upon the bench at the sessions when I was sent to prison, died in a while after; as old Thomas Preston, Rawlinson, Porter, and Matthew West, of Borwick. Justice Fleming's wife died, and left him thirteen or fourteen motherless children. Colonel Kirby never prospered after. The chief constable, Richard Dodgson, died soon after, and Mount, the petty constable, and the wife of the other petty constable, John Ashburnham, who railed at me in her house, died soon after. William Knipe, the witness they brought against me, died soon after also. Hunter, the jailer of Lancaster, who was very wicked to me while I was his prisoner, was cut off in his young days; and the under-sheriff that carried me from Lancaster prison towards Scarborough, lived not long after. And Joblin, the jailer of Durham, who was prisoner with me in Scarborough Castle, and had often incensed the Governor and soldiers against me, though he got out of prison, yet the Lord cut him off in his wickedness soon after.[37]

In concluding this brief study, reference might be made to one instance in the life of George Fox—the well-known Lichfield incident—which perhaps best points to his instability. In the year 1650 Fox went to Derby, where, because of his severe denunciations, he was arrested for blasphemy. He was confined in the Derby prison for one year. Upon being released from jail, he was physically and mentally weakened, and in this condition he performed the most singular act of his life which had the appearance of mental and emotional derangement. Fox gives us his own account of what happened:

> Being again at liberty, I went on, as before, in the work of the Lord, passing through the country into Leicestershire, having meetings as I went; and the Lord's Spirit and power accompanied me.

[37] Journal, p. 457.

As I was walking with several Friends, I lifted up my head and saw three steeple-house spires, and they struck at my life. I asked them what place that was. They said, "Lichfield." Immediately the Word of the Lord came to me that I must go thither. Being come to the house we were going to, I wished the Friends to walk into the house, saying nothing to them of whither I was to go. As soon as they were gone I stepped away, and went by my eye over hedge and ditch till I came within a mile of Lichfield, where, in a great field, shepherds were keeping their sheep.

Then was I commanded by the Lord to pull off my shoes. I stood still, for it was winter; and the Word of the Lord was like a fire in me. So I put off my shoes, and left them with the shepherds; and the poor shepherds trembled, and were astonished. Then I walked on about a mile, and as soon as I was got within the city, the Word of the Lord came to me again, saying, "Cry, 'Woe to the bloody city of Lichfield.'" So I went up and down the streets, crying, "Woe to the bloody city of Lichfield!" And no one laid hands on me.[38]

Fox's only explanation of this most remarkable eccentricity was that it was in some way connected with the martyrdom of a thousand Christians in the time of Diocletian.[39] Some have held that this very peculiar occurrence marks Fox as an insane man. Others have been inclined to believe that the Lichfield incident simply represented an outburst of uncontrolled enthusiasm. Still others have attempted to show that Fox was clever enough and wise enough to make use of a very effective method of producing a desired impression—an object-lesson far more powerful than if he had merely preached a denunciatory sermon. Such an explanation of this extraordinary episode is not at all convincing; it does nothing more than offer an apology for a very strange performance.

[38] Journal, pp. 132–133.

[39] This strange act, as Rufus Jones suggests, was probably due to a horror arising from a subconscious memory of what he perhaps had heard in childhood from his mother concerning the wickedness of that place. She must have told him of the burning of Edward Wightman in this city during the year 1612, for this bloody deed was fresh in the minds of many at the time. The city had a black history; Lichfield actually means "field of dead bodies." This subconscious memory probably had strong suggestive power over Fox at this particular time, when, due to his worn condition, he was not able to resist suggestions. (See Rufus Jones' footnote comment in the Journal, pp. 133–134.)

There is a more reasonable explanation—an interpretation in line with our general viewpoint that Fox, though perhaps not definitely psychotic, was certainly neurotic. He had just been released from Derby prison, in which his nervous temperament had been set on edge by the long confinement. On being released, his new freedom turned his brain. The sight of church-steeples in Lichfield caused an uprush of his complex into consciousness, he became extremely emotionalized, and there followed in this state of excitement and confusion a strange automatism, in which his accumulated energy exploded in a pathological manner. This performance was the work of a nervous invalid, not the work of a divinely inspired prophet. What George Fox needed was the services of a physician and a psychiatrist.

[MS. received January 18, 1931]

INHIBITION, FACILITATION, LEARNING: SUMMATION OF STIMULI

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Of all the concepts used by the psychologist there is no other on which there is more general agreement than on that of inhibition. It is true that nothing is known about this strange phenomenon and it is true that there are about as many theories of the underlying mechanism as there are authors on the subject, but there are very few who doubt that it is a property of the organism. If consensus of opinion could be accepted as truth the belief in inhibition would be a firmly established fact. But since the standardization of error is not unknown to science it may be well to analyse the situation. In part this was done by Dodge a few years ago. His was an excellent statement of the problem and evaluation of the concepts which have been offered to explain the phenomenon. But, as Dodge [1] pointed out, the solution of the problem has not yet been presented. Our psychological and physiological work will have made great progress before we shall thoroughly understand the whole group of phenomena which we commonly call inhibitions.

A term may be defined in any way and may be used with complete justification so long as it remains within the limits of the definition. The psychologist may then use the term if his definition is not in opposition to related facts. Since most of us believe in the essential unity of nature we have sought to understand our observations in the light of the neural mechanism underlying behavior, and in the absence of knowledge of the mechanism we resort to somewhat free association. If, however, we wish to conceive of the organism ateleologically,

[1] R. Dodge, The problem of inhibition, PSYCHOL. REV., 1926, 33, 1–12; Theories of inhibition, Part I, PSYCHOL. REV., 1926, 33, 106–122; Theories of inhibition, Part II, PSYCHOL. REV., 1926, 33, 167–187.

understandable in terms of energy change, there are certain principles of energy change, sometimes called the natural laws, which must control our associations. Thus, to the mechanist, any concept which is in opposition to these known principles is invalid.

A re-examination seems particularly advisable at the present time because of the important position which the concept is rapidly assuming in the field. The work on the conditioned reflex, particularly that coming from Pavlov's laboratory, the work of the psychoanalysts and abnormal psychologists, our meager and tantalizing data and our demand for explanations, all have combined to give a marked impetus to its spread and adoption. It is now frequently said to be fundamental to psychology, to be the very corner-stone on which the whole structure of mental life is built. Its forms have become so numerous that classifying inhibitions is now a vogue.

The purpose of this paper is twofold. First, we wish to evaluate the present concepts of the mechanism underlying inhibition in terms of the natural laws and primarily in terms of the law of Least Work or Minimal Change. Second, we wish to present a suggestion of the possible mechanism underlying not only the observations which we have termed inhibition but also many less mysterious reactions. It may be charged that we are suggesting a panacea and our only defense is that the nervous system seems to be unitary now just as it was in the days of Hughlings Jackson.

The concept came into use in psychology through the German physiology of the past century.[2] It seems to have originated in one of Setchenow's minor experiments and its history is intimately connected with that of the localization of functions in the cerebral cortex. Setchenow [3] conceived that his observations were due to the activity of specific inhibitory

[2] For a more complete development of the history of the concept see F. Fearing, Reflex action, 1930, 187–217; or J. F. Fulton, Muscular contractions, 1926, 313–363.

[3] J. Setchenow, Physiologische Studien über die Hemmungsmechanismen für die Reflextätigkeit des Ruckenmarks im Gehirne des Frosches, Berlin, A. Hirschwald, 1863, 51 pp.

centers in the optic lobes. Goltz [4] adopted the term and gave it a somewhat different meaning. He had already assumed that in all forms of vertebrates similar segments of the central nervous axis have similar functions. But when it was demonstrated by Steiner [5] that similar lesions in the nervous system of different forms do not produce similar limitations Goltz [6] adopted the concepts of shock and inhibition. He assumed that the shock of the operation inhibited the activity of the levels below the operation and that this inhibition was greater in the case of the higher than of the lower forms. Goltz, however, failed to explain away evolution. As has been pointed out by Pike,[7] Goltz' concept postulates that the species be immutable.

Contemporaneous with Goltz many other theories of inhibition arose. The more important of these have been adequately considered by Dodge [8] and shown to be of little scientific value. Particularly effective is his criticism of the drainage theory, whose outstanding proponent has been McDougall. Recently some other theories seem to have gained popularity. Those offered by the psychoanalysts have been too mystical to warrant serious consideration but we may profitably examine three others. The first is that of Pavlov.[9] His conception is closely related to that of Setchenow but perhaps goes somewhat beyond it. Pavlov postulates that to every effector there are two kinds of peripheral nerve supply, one of

[4] F. L. Goltz, Das Hund mit verkurzen Ruckenmark, *Arch. f. d. ges. Physiol.*, 1896, 63, 362–400.

[5] J. Steiner, Die Functionen d. Centralnervensystem und ihre Phylogenese, Braunsweig, F. Vieweg und Sohn, 1885–1900.

[6] F. L. Goltz, Der Hund ohne Gross hirn, *Arch. f. d. ges. Physiol.*, 1892, 51, 570–614.

[7] F. H. Pike, The general phenomenon of spinal shock, *Amer. J. Physiol.*, 1909, 24, 124–152, points out that if similar functions are found in similar levels of the nervous system in all vertebrates (the segmental theory of localization) then there can have been no wandering of function towards the anterior end of the nervous axis, the species have been immutable and there can have been no evolution from a lower to a higher form.

[8] The theories considered by Dodge are: specific inhibitory nerve centers, wave interference, nerve metabolism, drainage, refractory phase, and the chemical. The three concepts considered in the present paper may be fitted into one or another of these classifications.

[9] I. P. Pavlov, Conditioned reflexes, 1927.

which is excitory and the other inhibitory in function. The concept is vague and but poorly worked out and is in opposition to the well supported conclusions as to the nature of the nerve impulse.[10]

The second theory which has gained some favor recently is that of chronaxie.[11] Lapicque [12] postulates that under normal conditions nerves and their muscles are isochronous, that is, the chronaxie of the one is a multiple of the other. When this isochronism is lost we have the condition of inhibition. To such a concept we may raise several objections. That there is a condition of isochronism between the normal nerve and its muscle is only an hypothesis and is quite without experimental proof. The assumption that heterochronism will result in inhibition is based upon a wave analogy and is doubtfully applicable to the nervous system. Finally, it would be a little difficult to conceive of an agent which could change the chronaxie as rapidly as the facts necessitate.

The third and most important theory is that presented by Dodge. Dodge has worked out a mechanism of inhibition which is supported by experimental findings and which seems to place a question mark after the all-or-none law. Dodge saw that the refractory phase could not be employed to explain inhibition if an adequate stimulus [13] were necessary to bring about a refractory phase. To determine whether the inadequate stimulus might set up a refractory phase, Dodge used the knee-jerk and lid reflex. The knee-jerk apparatus was so designed as to present a stimulus which was inadequate to cause a knee-jerk and follow this at 1/300 sec. with a second stimulus which, when used alone, was sufficient to produce a movement. He found that after the inadequate stimulus had been administered the second was no longer adequate. This he believed was good evidence that a refractory phase might be set up by an inadequate stimulus. Dodge is most cautious in

[10] There are no known 'kinds' of nervous energy and not the slightest experimental support for such an assumption.

[11] Waller's term 'characteristic' and Lucas' 'critical time' are synonymous with chronaxie.

[12] L. Lapicque, *Science*, 1929, 70, 151–154.

[13] By adequate Dodge meant capable of arousing the reflex response.

his contentions and he points out that his results, though by no means final, are not in line with the all-or-none law. This conflict between law and observation may be more apparent than real and we shall return to Dodge's work after developing the present conception.

In our discussions of inhibition, we frequently cite such physiological examples as the inhibitory relation of the cardiac branches of the vagi nerves and the accelerator nerves to the heart. The activity of the vagi is said to inhibit the activity of the accelerators. Since the neurophysiologists admit that they know little or nothing of the organization of the mechanism which innervates the heart,[14] we may be a little hasty in declaring that it is one of reciprocal inhibition or inhibition in any other form. Another of our examples is drawn from the activity of antagonistic muscle groups. It is said that when the agonist goes into activity the antagonist is relaxed; activity of the agonist inhibits that of the antagonist. Nothing is more fallacious. As has been shown by Beaunis,[15] Pike and Tilney [16] and, more recently, Dodge,[17] innervation of the agonist is attended by simultaneous innervation of the antagonist, and if the tendons are detached from the bone which they move and are attached so as to record movement, they will be seen to contract simultaneously. Again we have been hasty with the use of our term. It has been said that walking inhibits running. This is equivalent to saying with regard to an office elevator that the trip up inhibits the trip down or that a baseball in flight is inhibited from falling by the force driving it up. Such a use of the term 'inhibition' is, it seems, quite legitimate.

Quite apart from the mechanism or illustrations, let us

[14] The same may be said of any of the physiological systems with the possible exception of respiration. Little of the physiological work has been directed to the thorough understanding of these systems. With few exceptions, inhibition has been the catch-all for neurophysiologists, much as instinct was for the psychologist a few years ago.

[15] H. Beaunis, *Gaz. Med. de Paris*, 1885, n. 28, pp. 325, 337; *Compt. rend. Soc. de biol.*, Paris, 1885, 8 s., 2, 345–347; *Arch. de Physiol. & Pathol.*, 5e série, 1889, 1, 55–69.

[16] Pike and Tilney, *Arch. of Neur. & Psychiat.*, 1925, 13, 289–334; *L'Encephal*, 1926, 21, 305–351.

[17] R. Dodge, PSYCHOL. REV., 1927, 34, 241–272.

examine the factors which a phenomenon such as inhibition necessitates. All of the neural concepts previously presented, excepting that of Dodge, have necessitated that energy be delivered to some structure which nullifies the effects of energy that has been or will be delivered to the structure. As for example, in Pavlov's concept, energy is delivered to the effectors by the inhibitory nervous system to nullify the effects of that delivered to the effector either previously or later by the excitory nervous system. The experimental work shows rather conclusively that the nerve impulse is explosive in nature. It is a little difficult to understand how one explosion can stop another that has started or that will start. Further, supposing one could devise some way of having one explosion nullify another, the same negative result could be obtained by no explosion. We are delivering energy equally and oppositely, a sheer waste. If organisms evolved in a manner comparable with the mechanistic conception, they must at all times have been subject to the laws of nature. One of these general principles, the law of Least Action or Minimal Change, states that processes tend to occur with the least expenditure of energy.[18] Neural inhibition involving a useless expenditure of energy is contrary to the law of Minimal Change. It follows, then, that if this opposition to the law of Minimal Change exists, organisms which demonstrate this phenomenon did not develop subject to the natural laws and are, therefore, not natural events. Few of us will be willing to let organisms pass out of the realm of science. If our arguments are valid, it becomes necessary to give up the belief in inhibition. The removal of this 'corner-stone' will probably not bring our whole psychological structure tumbling down about us. It is even possible that we may be able to describe the observed phenomena in terms wholly within the limits of possibility and the natural laws.

About the time that Setchenow presented his concept of inhibition, he also observed that a nerve cell might be stimulated by a series of impulses, none of which were adequate in

[18] Many applications of this law will be found in the evolution of organisms. For example, the change in shell form from the orthoceras to the chambered nautilus.

themselves to cause the nerve cell to react.[19] This property of the nerve cell has been investigated and affirmed by many physiologists since and is now established as one of the more or less isolated facts of neuro-physiology. A few years ago, Pike,[20] then working on the organization of the respiratory mechanism, came to the conclusion that in any reaction afferent impulses from at least two sources are essential.[21] When the afferent sources are decreased to one, the mechanism collapses. These statements may be clarified by a few examples.

1. The organization of the respiratory mechanism involves afferent impulses from three sources: the phrenics, the vagi and the intercostals. Any one of these sources may be removed by accident or design and respiration goes on, only slightly affected. If any two sources are injured, leaving the other source intact, the animal shows grave respiratory difficulty and may die.[22]

2. The mechanism for maintaining posture involves afferent impulses of three sorts, kinæsthetic, visual and vestibular.[23] In tabes dorsalis the kinæsthetic impulses are cut off. When the patient closes his eyes, the remaining impulses from the vestibules are not sufficient and the patient falls.

3. A puppy may recover from the removal of the inner ears so that he walks and runs well, but in jumping from a table he loses the impulses from the legs while he is in the air.

[19] Setchenow, *Physiol. Studien*, u. s. w., Berlin, 1863.

[20] F. H. Pike and H. C. Coombs, Functional organization of the nervous mechanism of respiration, *Science*, 1922, 56, 691–693.

[21] This statement is not original with Pike though he is the first to give it experimental support. Jackson, Eckhart, Lewes, Wundt and James held that this was an important consideration in neural function. I am not aware that any of these held that every reaction depended upon a summation of stimuli.

[22] It is a fact that an animal may live when only one respiratory afferent source remains intact. This would seem at first blush not to accord with the above statement, but it must be remembered that the picture is complicated somewhat by the factor of central stimulation. As the CO_2 builds up in the alveolar air the respiratory center in the medulla is directly stimulated by the bloodstream and impulses are propagated from it over the efferents whose afferents have been injured.

[23] Summation in posture was first noted by Marshall Hall and later by Michael Foster though the finding is usually attributed to Rhomberg. See Fearing, Reflex action, pp. 135 and 176.

Vision alone is not sufficient to enable him to break his fall and he strikes on his chin.

4. In 'flying blind,' the condition in which there are no visual cues as to which is up and which is down, the aviator frequently goes into a tailspin, from which he may recover, if he has enough altitude. In flying, visual, vestibular and tactile impulses normally operate to maintain posture. On entering a dense fog, vision is eliminated. The end-organs in the vestibules, it will be recalled, are stimulated only by acceleration. The aviator might get up a speed of rotation about the longitudinal or transverse axis of the plane of one degree a minute, without stimulation of the vestibules. With the constant speed achieved, the vestibules can not be stimulated by the rotation. The tactile sensations are not sufficient and the plane, when it has rotated far enough, slides off into a tailspin. But, in falling, the vestibules are stimulated and, with the two sources of afferent impulses, the flyer may right his plane, only to repeat the performance in a short time.

Pike's more recent work, in some of which the present author has collaborated, shows that there is a summation of impulses on the motor horn cells as well as on the afferent side. We have shown in these investigations [24] that impulses from the rubro-spinal tract, pyramidal tracts and possibly from the reticulo-spinal, vestibulo-spinal and intra-spinal pathways all enter into many and, we are inclined to believe, all reactions. If, in every reaction, there is a summation of stimuli on the afferent and efferent sides, it is not unreasonable to assume that, in order for cerebration to occur, there must be a summation of impulses in the cerebral cortex. If we make this assumption,[25] it seems possible to explain the observations which we have commonly regarded as inhibition.[20]

Let us take the case of Pavlov's dog to demonstrate the

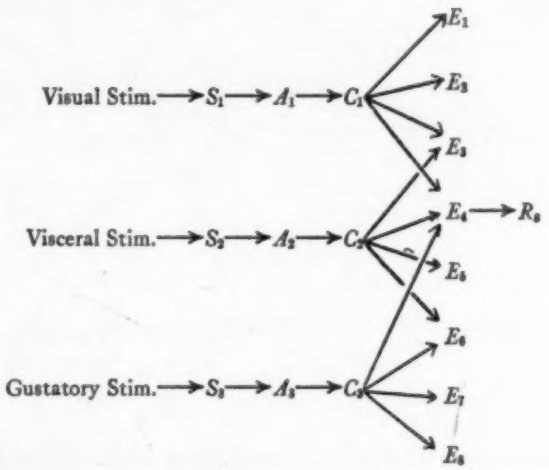
[24] Pike, Ellsberg, McCulloch & Chappell, *Arch. Neur. & Psychiat.*, 1930, 23, 847–868; Pike, McCulloch & Chappell, *Amer. J. Physiol.*, 1930, 96, 678;] Pike, Ellsberg, McCulloch & Chappell, *Amer. J. Psychiat.*, 1931, 10, 567–594; P[illegible]e and Chappell, *Science*, 1930, 71, 76.

[25] This assumption is not original with us. See Lucas, Conduction of the nervous impulse, p. 54 and following. It is so common that we sometimes forget that it is an assumption.

present conception. We shall consider the formation of the conditioned response and its 'inhibition.'

The normal dog salivates not to acid being put on its tongue but to an aggregate of stimuli, visual, auditory, visceral and others. For the sake of convenience, we shall restrict ourselves to three which are evidently of importance. These will be gustatory, visual and visceral.

Our paradigm for the reaction in normal salivation will be as follows:

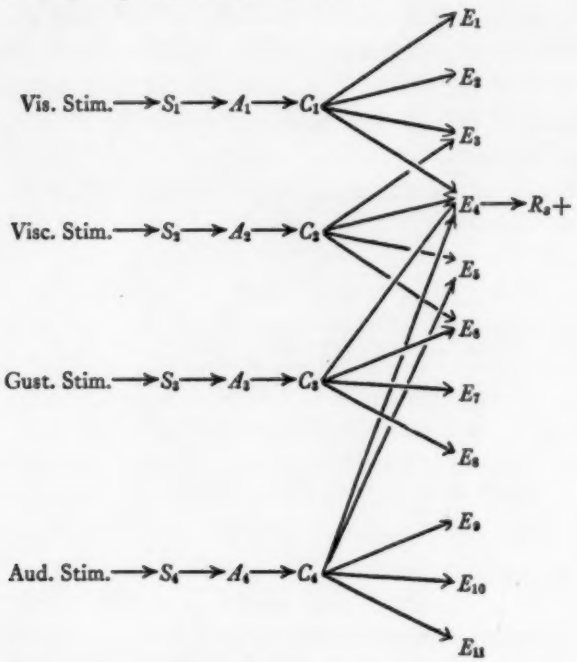


in which S is the sense organ, A the afferent mechanism, C the central mechanism, E the efferent mechanism and R the response. It will be observed that summations are represented on three efferent mechanisms.[26] Such summations, as we have assumed, on E_3 and E_6 might occur without producing a response if the summed stimuli were inadequate or if the time interval between the delivery of the two impulses were long.[27] Sufficient summation has occurred only on E_4, which leads to the response of salivation.

[26] For the sake of simplicity the central summations are omitted in the diagrams.

[27] See Bubnoff und Heidenhain, *Arch. f. d. ges. Physiol.*, 1881, 26, 137–200, for a discussion of time relations. For a brief review see Lucas' Conduction of the nervous impulse, p. 52ff.

When the conditioning is started, we have a situation which we may represent as follows:



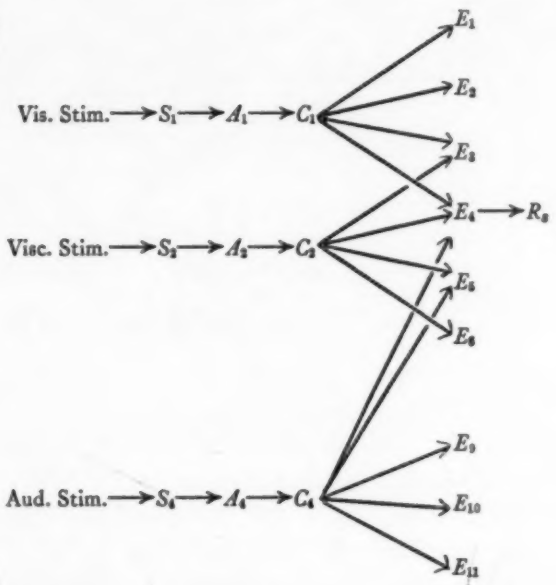
in which the auditory stimulus, 4, is a bell. If the auditory stimulus also innervates E_4, the response should be greater in this case than in the former, since more work is now being done on the effector. This is borne out by the experimental findings. The first effect usually observed in conditioning is that of 'facilitation' of the unconditioned response.

As we have pointed out elsewhere,[28] in learning, work is done on the anterior end of the central nervous axis and is stored there in some form. This stored energy may take the form of a growth, a change in permeability or any one of a number of forms. In the literature the assumption is generally made that the change occurs at the synapse. This is by no means necessary and we do not limit ourselves to it.[29]

[28] M. N. Chappell, Chance and the curve of forgetting, PSYCHOL. REV., 1931, 38, 60–64.

[29] There is some reason to believe that a change takes place within the cell itself rather than at the synapse.

Thus, in the above illustration, the energy delivered causes a change in the central nerve cells, as between C_{1-2-4} and E_4, such that when the gustatory mechanism is not aroused the response R_s will still occur. This we may represent as follows:



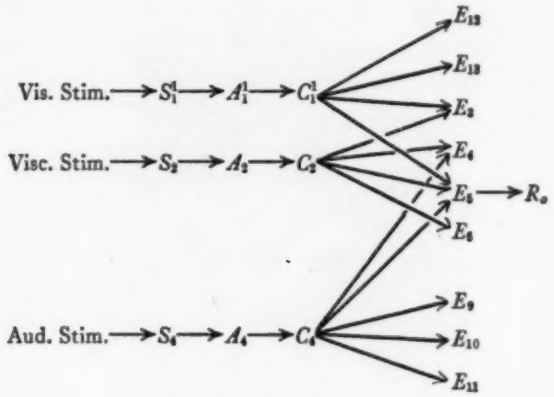
The summation is still sufficient on E_4 to produce the response of salivation.

We may now consider the inhibition [30] of the salivary response. We will illustrate the form which Pavlov has termed 'external inhibition.' Supposing that the conditioned response is set up and the laboratory conditions change. The illumination is decreased by a cloud passing in front of the sun, to make further use of Pavlov's example.[31] The reaction changes because the stimuli no longer sum up on the same

[30] Hans Driesch has defined regulation in essentially the following terms: It is the return of a cell or tissue or organism, or the tendency to return, to its former condition. Following a period of excitability a nerve fibre or cell tends to return to its former condition, that is a state of rest or inactivity. It will not again become active until acted upon by another stimulus (Du Bois Reymond). If impulses insufficient to excite a nerve cell are reaching it, it will cease to act and there is no necessity whatsoever for postulating inhibition when there is mere failure of response, even when the stimulus is increased.

[31] I. P. Pavlov, Conditioned reflexes, 1927, p. 44.

effector. The new visual stimulus will no longer be delivered to a sense organ S_1, but rather to the sense organ in a different condition which we will call S_1^1. Our paradigm will then be as follows:



The adequate summation of stimuli is no longer on the efferent mechanism E_4 but is now on E_5 and R_o occurs which is some response other than that under observation. 'Inhibition' in such a view becomes nothing different from other reactions; there simply is not sufficient summation on E_4.

We are now in a better position to consider Dodge's experimental work, the apparent digression from the all-or-none law. Afferent impulses from what sources enter into the production of the patellar reflex? Obviously one of the sources is the skin over the patellar tendon as well as the eyes, ears, viscera and many others. Dodge's 'inadequate' stimulus was inadequate to set off all the afferent sources essential to the patellar reflex but it was not inadequate to set off at least one of them. Dodge doubtless did *feel* the 'inadequate' stimulus. It must then have been adequate to set off that afferent mechanism. The previously adequate stimulus arrives, then, during the truly refractory phase of the part of the mechanism that has been adequately stimulated and has reacted. Under these circumstances, there is not adequate summation and the jerk does not appear. If, now, other afferent sources are stimulated, audition, for example, the

summation may become adequate even though some of the afferent mechanism is in a refractory phase. This is beautifully illustrated in Dodge's charts,[32] of which he says, "In the case of the last record, there was a disturbing conversation in the room. This was noted on the record as a suggestion of the cause of an enormous exaggeration." Interpreted in the light of the present conception of summation, Dodge's results are not in any way conflicting with the all-or-none law. The present concept is quite in line with his findings. In the extreme case with which he has worked the refractory phase becomes important, and it may possibly be so in many other reactions, although this seems rather doubtful. It is quite possible that in the case of the refractory phase we have been closely attending a relatively unimportant detail of neural activity to the exclusion of more important ones.

Inhibition and facilitation have always been linked together.[33] It is usually held that one is in some way the reverse of the other. Perhaps it would be nearer the truth to say that they are the same phenomenon. Consider the knee jerk; the force and excursion of the leg are increased if the subject is squeezing a dynamometer when the patellar tendon is struck. This is 'facilitation.' But what happened to the dynamometer? The squeeze is decreased when the tendon is struck. This is 'inhibition.' Some of the impulses which summed up on the final common pathway to the arm and shoulder are now summed up on that to the leg. The squeeze is 'inhibited' and the jerk 'facilitated.' There is a change in direction of summation but hydraulic analogies are not essential to the explanation of the phenomenon.

The psychological literature is filled with cases which may be seen to be due to summation of stimuli. In the light of the present argument it is easy to understand why Morgan's[34] subjects did more work under conditions of 'distraction' than

[32] R. Dodge, PSYCHOL. REV., 1926, 33, 183.

[33] We quite agree with MacDougall "that inhibition appears always as the negative or complementary result of a process of increased excitation in some other part."

[34] J. J. B. Morgan, *Arch. Psychol.*, 1916, No. 35. These results are usually interpreted as being due to the intervention of effort or some other inner force.

without these added stimuli, and why Todd [35] found that reaction times decrease with an increasing number of stimuli. Summation of stimuli will also be seen to be the factor underlying Feré's [36] concept of dynamogenesis. Order comes out of the conflicting findings with regard to the localization of functions in the cerebral cortex in the light of such a view.[37]

We have limited ourselves to illustrating the underlying principle in only one of the many classes of 'inhibition' but it may readily be seen that the other classes, including negative adaptation, will yield to the same treatment. The general principle is the same in all. The situation changes and the new impulses cause a change in the locus of adequate summation on the effector mechanism.

The question may well be asked, does the present concept coincide with the law of Minimal Change? The figure [38] answers this question.

The figure, on whose ordinates are plotted power and time, represents the energy delivered to the nerve cell to cause it to react. Curve I is approximately that which would represent the work done on the nerve cell by one adequate stimulus. Curve II represents that done by the summed stimuli if they are delivered in the manner indicated by the dotted lines. The saving of energy by the process of summation is indicated by the shaded area. The greatest saving will occur when the summed impulses are delivered simultaneously and, obviously, as the interval between the summed stimuli increases, the time will come when stimulation by summation will require the

[35] J. W. Todd, *Arch. Psychol.*, 1912, No. 25.

[36] Feré, Sensation et mouvement, Paris, Alcan, 1887.

[37] Closely allied and fundamental to the study of the localization of function is the study of modality of learning. In the light of the present concept we may understand how so vast an amount of work has brought such insignificant results. Thus Lashley, for years, has been searching the cerebral hemispheres of the albino rat for a visual learning center without realizing that there is no such thing as visual learning. And all that while he has known that without certain afferent impulses from his stomach the rat rarely learns a problem. Hughlings Jackson, Wundt and James have been overlooked.

[38] It is not to be thought that the curves presented accurately indicate what happens to the nerve cell. The lack of accuracy in no way influences the argument. It is apparent that a small amount of energy may be delivered in less time than can a large amount. If the same potential is achieved in less time, a saving must result.

expenditure of more energy than will stimulation by one adequate stimulus. Since we conceive that in the nervous system those summed impulses are delivered in close succession it may be seen that the present concept is well in line with the law of Least Work.

To sum up, we have shown a fundamental fallacy in the concept of any form of neural inhibition. It is in opposition to the law of Minimal Change. In building a concept which will explain 'inhibition,' we have made two assumptions, which are partially supported by experimental evidence. These are: (1) a summation of impulses occurs in the anterior end of central nervous mechanism and (2) a stimulus may deliver energy to a number of efferent mechanisms. That response is made on whose efferent mechanism adequate summation occurs. 'Inhibition' is seen to be a case of summation on some effector mechanism not under observation. 'Inhibition' and 'facilitation' usually occur simultaneously. They are two parts of the total picture of summation of stimuli. Normal reactions, learning, 'facilitation' and 'inhibition' have all been regarded too narrowly. The present concept shows their essential unity. It is within the realm of probability and not in opposition to the natural laws.

[MS. received January 5, 1931]

REASONING AND LEARNING

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Our definitions of learning, insight and reasoning are so vague and elastic that they convey little which is of scientific value. The conventional laws of association [1] are, however, specific and can be subjected to experimentation. Because the definitions of intelligent behavior are usually vague, it is not surprising that explanations of behavior which have recourse to the mechanical principles of the laws of association have been preferred.

At the present time many students of behavior are agreed that the laws of association are quite inadequate for explaining certain types of behavior, but definite experimental definitions of alternatives are still lacking. Insight has not been defined so as to be experimentally useful. The same behavior data may indicate evidence of insight to one experimenter and the absence of it to another.

The purpose of the present paper is to (1) define learning, insight, and reasoning in experimental terms; (2) harmonize the experimental data obtained from studies on both rats and man; and (3) suggest a mechanism which accounts for the spontaneous appearance of new behavior integrations.

I

In 1929 I published a study (7) in which an attempt was made to demonstrate that certain types of rat behavior could not be explained by the traditional laws of association. The experiments in principle consisted of giving the rat two iso-

[1] The laws of association are here understood to be the association or combination of two things which have been experienced in contiguity (spacial or temporal); the strength of the associative bond being a function of the recency and frequency of the experience, and perhaps also of the intensity and primacy of the experience. Physiologically these combinations are explained by a lowering of the resistance at the synapse, because of use.

lated (non-contiguous) experiences and seeing whether the essentials of each of these could be combined in such a manner as to reach the goal. It was concluded that (1) rats could combine the essentials of two isolated experiences in such a manner as to reach the goal; (2) such combinations were not reducible to the laws of association; and (3) such patterns of behavior characterized reasoning.

Dashiell (**2**) recognizes the interpretation of results given (i.e., that the rat combined the essentials of two isolated experiences) to be an explanation of the facts, but presents what he believes to be alternative and simpler explanations. He writes (p. 54) "while such an interpretation is certainly relevant and covers the facts, the present writer is not altogether convinced that simpler explanations are not possible." Simpler interpretations are then given.

As it is granted that 'the combination of two isolated experiences' does account for the facts, it remains for us to show that the alternative explanations are inadequate. In general the tests used for demonstrating the ability of rats to combine two isolated experiences may be described as follows. A rat was allowed to become familiar with a certain territory (*e.g.*, a room). The gaining of such familiarity was called Experience 1. Then, with food placed on a table, the rat was made to run an elevated pathway to the food.[2] This run was called Experience 2. In the test the animal was placed at a point within the territory with which it had become familiar in Experience 1. From this point the animal would have to go to the elevated pathway to obtain food.

After the experimental conditions had been varied in many different ways and chance solutions had been excluded, it was concluded that the rats reached the goal by combining the essentials of Experience 1 with Experience 2.

Dashiell suggests (p. 54) that the rat's response to the starting point of the pathway may have been a direct response to a detail in the environment. Experimental checks, however, showed that the starting point of the pathway offered

[2] This pathway was placed within the explored territory, but was not present during the exploration period.

neither visual nor olfactory cues, and consequently was not in the animal's perceptual environment. Rats failed when either Experience 1 (knowledge of the territory) or Experience 2 (learning pathway to food) was omitted, but succeeded when the test run was made in total darkness. If the response were determined by a detail in the rat's environment the results should have been reversed. But if we say that the rat solved the problem by combining parts of two isolated experiences, the results obtained are to be expected. The rat could not combine two experiences when only one of them had been given.

A second alternative, according to Dashiell, is that the starting point of the pathway was an enhanced stimulus. To say that it was enhanced seems to be saying no more than that it was favored by the rat. That is, of course, the fact. The question is, how was it enhanced? In order to explain this we must postulate that two isolated experiences came together. Consequently this alternative seems not to be a substitute explanation, but rather an alternative way of describing the rat's behavior. In my monograph (p. 92) I pointed out that the starting point of the pathway may have become a more intensified experience, but that this in no way excluded the interpretation of two isolated experiences being combined.

In a situation in which the location of the food was known to the rat, but in which the indirect route to the food was unfamiliar (Experience 2 omitted), rats when running around the pathway failed to take the turns which lead in the direction of the food in preference to those which lead away from the food.[3] Dashiell considers the results of this experiment to be a disproof of intelligent behavior on the part of the rat. Yet if the pathway is unfamiliar to the rat, and only the position of the food is known, how was the animal to behave intelligently? The integration of a known and an unknown is an unknown.

However, on the basis of Dashiell's interpretation of his

[3] In this experiment (Experiment 9, p. 67) the rat was placed on a table next to food which was inaccessible because of a wire cage. A simple pathway, which was unfamiliar to the rat, led around to the food. This pathway contained 2 or 3 junctions at which points the animal could either turn away from or in the direction of the food.

own results the rats should have solved the problem. He found that (1) rats when running a maze tend to enter culs-de-sac which lie on the same side of the maze as the food compartment; and (2) no particular route to food will be learned when there are a number of routes of equal length, nevertheless errorless runs will be made. The rats learn to go in the right general direction, rather than depend on local cues from point to point. He concludes that the rat has a directional sense which aids it in its runs through the maze. This being the case my rats should have preferred the pathways which led in the direction of the food in the above experiment.

Dashiell says that the experiments on delayed reaction, in which gross bodily postures were used by the rat, suggested the concept of organic postures to him. The present writer has found (**8**) that under certain experimental conditions rats can delay their responses for 24 hours without the aid of gross motor attitudes. The conclusion reached from this study is that bodily postures are necessitated by the method of experimentation, rather than by conditions inherent in the nature of the task. If this is the case, a general orientation sense becomes much more difficult to explain.

The evidence for behavior patterns made up of two or more isolated experiences thus seems to be worthy of further consideration. There is also a very considerable amount of evidence for behavior patterns made up of contiguous experiences. It can hardly be questioned that when two things are experienced together in space or time they *may* become associated.[4] That they are combined because of their contiguity is fundamental to our theories of learning.

In a recent study (**11**) I postulated two possible types of behavior integrations; the one, made up of isolated experiences and called ability R; the other, made up of contiguous experiences and called ability L.

Tests were then devised to measure these possible types of behavior patterns. Test R measured ability R, and tests $R - L$ and $R + L$ measured ability R opposed by L and

[4] Lewin (4) found that the conditions of experimentation determined whether or not two successive nonsense syllables would be associated.

ability *R* in conjunction with *L*, respectively. Thus a habit was sometimes such as to favor an incorrect response, and sometimes such as to favor a correct response. Ability *R* always involved the combining of two isolated experiences.

Normal rats and rats with injuries to the cortex on the frontal half of the brain were then put through the tests.

The results showed that abilities *R* and *L* both were realities. Further, ability *R* was markedly affected by the brain lesion, and the extent of the effect was related to the extent of the injury. Ability *L*, however, was affected but little if at all by lesions involving as much as 40 percent of the exposed surface of the brain.

Thus we have further evidence to show that there are two qualitatively different types of behavior patterns. The one made up of contiguous experiences is in harmony with the usual concepts of learning. It implies that previous repetitions of the relationships involved in the behavior pattern are necessary. It therefore seems that integrations of this sort characterize learned behavior.

Behavior integrations which are made up of two or more isolated experiences are qualitatively different, and must be indicated by a different term. They arise without previous repetitions (except the repetition of the isolated experiences) and consequently are new. They are not the product of trial and error.

The term reasoning implies that something new has been brought about, and that in some way, past experiences have been manipulated. It therefore seems that behavior patterns made up of two isolated experiences characterize what is meant by behavior which is the product of reasoning.

On the basis of such experimental definitions of learning and reasoning, learned behavior depends for its integration upon the order in which past experiences occurred; whereas behavior resulting from reasoning depends for its integration upon the goal or end.

In learned behavior the goal furnishes the drive which sets off a pattern of response previously laid down. In reasoning (as it is defined in this paper) past experiences are reorganized.

That the combination of the essentials of two isolated experiences makes it possible for an animal to reach a goal implies a reorganization in terms of the goal. This ability thus makes reorganization of any experience possible. If two isolated experiences can be organized in terms of the goal, it then follows that two contiguous experiences may be reorganized. Consequently maze learning (although the experiences are contiguous) may be influenced by ability *R* as well as by ability *L*. With both abilities present any behavior pattern may be the product of an interaction of abilities *R* and *L*.

Problem-solving by insight is regarded by the exponents of Gestalt theory as qualitatively different from problem solving on the basis of trial and error. In the light of the above definitions of learning and reasoning, insight may be defined as the experience an organism has when two or more isolated experiences come together. Thus insight is the sudden experiencing of new relations.

II

With these experimental definitions in mind we may turn to some studies on human reasoning. In my study on 'direction' (**9**) the solution of a problem was broken into three parts. These parts were given as separate experiences to individual subjects who had been previously divided into groups. One group was told that the three parts when properly combined formed the solution to the problem; another group had the three experiences presented to it, but was not told that the parts had anything to do with the problem. A control group was not presented with the three experiences before being asked to solve the problem.

The results showed that these three groups did not differ in their attempts to solve the problem. Only 1 out of 52 subjects solved the problem.

Thus it seems that mere experience or even the selection of the pertinent experiences was not enough for solving the problem. The integration of the parts in terms of the goal was still lacking.

In order to aid in the integration of the separate ex-

periences an additional group was caused to see the problem in a certain way, *i.e.*, a certain point of view, or a start in a certain 'direction' was given in addition to the three parts. As a result 8 out of 22 subjects solved the problem immediately.

It was concluded that when a person attempts to solve a problem, he sees the difficulty to be of a certain sort. Past experiences are then organized in such a manner as to tend to overcome this difficulty.[5] Behavior or lines of thought which are directed at the overcoming of a certain difficulty may be characterized as the 'direction' in which a person is thinking. When the difficulty one attempts to overcome is wrong (leads to no solution), all consequent organization is in vain. The experiments showed that 'directions' were so decided and dominating that they caused helpful suggestions to be so applied as to fit in with the organizations of experiences which they were determining. Consequently many suggestions were useless and even misleading. Only when the direction in thinking was an attempt to overcome the correct difficulty were suggestions successfully used. Thus 'direction' determines which experiences will be facilitated and which will be blocked or inhibited.

In a further study (**10**) it was found that a suggestion might be successfully used even when the subject was unaware of having received it or even of having used it. This study indicated that the solution-integration came suddenly, and masked any cue which set it off. The solution of a problem is thus the sudden organization of a number of detached and isolated experiences.

The subjects' reports, however, were in harmony with a mental trial and error explanation of reasoning. Because the cue which brought about the solution was not experienced, whereas the previous unsuccessful attempts were experienced,

[5] For example, if two scientists were trying to stamp out a disease, one might see the difficulty to be that of making man immune to a germ; the other might consider the difficulty to be that of the prevention of the germ's spreading. Because these men see different difficulties they would make altogether different kinds of attempts to solve the same problem. The first would experiment with serums, the second would study the development and habits of the germ. Past experiences that would prove most valuable to the one man would be of no use to the other.

the unsuccessful attempts were reported. The solution appearing as a complete experience was thus regarded by the subject to be just another attempt at solving the problem. It is therefore easy to understand why trial and error theories of reasoning should have arisen.

Because the solution involved the sudden integration of parts of different experiences, new relations suddenly appeared, and brought with them a sudden change in the meaning of the elements involved. Thus we see why the *Gestalt School* insists that reasoning carries with it a sudden change in meanings.

III

We are now confronted with the problem of finding a fundamental principle which will explain how the end, which involves the overcoming of a certain difficulty, may organize the essentials of certain isolated experiences.

Elsewhere (**9**, p. 139) I suggested that the 'direction' which is set up when a person is trying to solve a problem seemed to be a field of strain. Such a field of strain must determine the organization of experiences, and must inhibit certain past experiences and facilitate others.

The results of unpublished studies on association by Shepard (**12**) and by Shepard and Fogelsonger (**13**) clearly show the inadequacy of a drainage theory for explaining certain cases of reproductive inhibition. Shepard's concept of a 'pattern of stress' seems to be a necessary assumption for an explanation of their results.

The results from a study by Lewin and Zeigarnik (**5**) give further justification for the use of a 'field of strain' concept. They studied the effect that the non-completion of a task had on memory. A series of twenty different tasks (puzzle pictures, modeling, bead stringing, etc.) were presented to a large number of subjects. Some of these tasks were allowed to go to completion (*i.e.*, the subject was permitted to finish the task); some were interrupted and left uncompleted; while the remaining tasks were interrupted, but completed later in the experiment. The results show that tasks which were completed either with or without interruption were recalled only

half as well as tasks which were left uncompleted. Thus the non-completion of a task rather than the interruption determines the ease with which the task is recalled.

Subjects who performed the experiment in a fatigued condition and recalled the tasks in a refreshed state did not show a difference in their ability to recall completed and non-completed tasks, but subjects who performed the experiment in a refreshed state and recalled the tasks in a fatigued condition did show the difference. Emotional excitement after the completion of the experiment removed the difference in subject's ability to recall completed and non-completed tasks. Children were more affected by the non-completion of a task than were adults. Finally, the difference between the ease of the recall of completed and non-completed tasks was greater for tasks which had a definite point of termination (*e.g.*, modeling a dog) than for tasks which had no definite point of termination (*e.g.*, putting beads on a string).

The authors conclude that a task which has a definite goal (termination point) sets up an energy system which is relieved when the task is completed. An interruption blocks this release so that the energy remains and affects recall. In a fatigued condition the energy necessary for such a system is not available, whereas an emotional experience destroys the system. Children (and certain adults), because they enter into the experiment in a natural way, are more affected by a blocking of the energy system than adults who think they are being tested and thus are influenced by other factors. Finally, tasks with no definite end cannot set up a well-organized energy system, and thus are not markedly affected by non-completion.

These conclusions are based on the results of a well-controlled experiment, and are further substantiated by a study by Lewin and Ovsiankina (**6**). The results of this study showed that the non-completion of a task established a decided tendency to complete the uncompleted tasks on the first available opportunity.

In the light of modern physiology a field of strain can hardly be regarded as an empty concept. The physiological

gradient of Child (1) is a field of strain. Physiological gradients are present whenever there is a source of stimulation or a difference in growth rate. This physiological field is a fundamental concept in general physiology and is used to explain physiological organization. In psychology, organization also requires an explanation, and for the present at least, a similar field hypothesis seems necessary.

The following examples illustrate the use of the field concept for the interpretation of behavior.

In a hungry rat there is present (1) a hunger drive, and (2) the sensory experience of food *in a certain surrounding*. These two factors set up a field of strain which causes the animal's activity to be such as to tend toward the attainment of the food, and a consequent disruption of the field. The field of strain will thus determine the animal's activity, whereas the complexity of the animal's nervous system will determine the types of behavior of which the animal is capable.

In reasoning the field of strain is set up by (1) the desire to solve the problem (reach the end), and (2) the knowledge of the end, the attainment of which offers certain difficulties. The solution of the problem would be the organization of parts of different past experiences in such a manner as to overcome a certain difficulty.[6] If the difficulty is seen to be one thing, the behavior is of one character; if it is seen to be something else the behavior is of another character. There are thus different types of behavior which depend on the difficulty an individual is attempting to overcome. In other words the types of behavior depend on certain 'directions.' Whether or not a problem is solved depends on (1) whether the 'direction' or field of strain is adequate; *i.e.*, whether the individual is trying to overcome a practical difficulty; and (2) whether a certain combination of parts of past experiences will result when the field of strain is adequate.

[6] We are here discussing only solutions which are new. If a situation calls up the solution of a past problem which is found to be satisfactory, then such a solution is not new at the time and is therefore not a case of reasoning. Most situations do arouse organizations which have been built up in the past. Sometimes such attempted applications solve problems, but very often they prevent a solution because of their tendency to persist. Past organizations when functioning in a problematic situation produce what we have called 'habitual directions.' (See study on direction, pp. 137–141.)

The localization of the organization of such types of behavior will be a matter of localizing fields within which such organizations arise. There can be no point for point localization in the older sense of the term, because the neural pathways are not specific; they depend on a field within which nervous impulses may take any number of possible courses. This concept of field localization is stressed by Herrick (3) who has found it necessary to take this position after a consideration of results obtained in recent studies related to anatomy and behavior.

Thus the concept of reasoning presented in this paper is in no way out of harmony with modern physiology and neurology. Our older psychological concepts are, however, based upon a neurology that neurologists no longer accept as adequate.

IV

It may be argued that the concept of a 'field of strain' is so general that it has no consequences at the present time, and is therefore no addition to our knowledge. Let us therefore examine a few problems which require investigation as a result of the concept.

We may illustrate in the following manner how the concept of a field of strain may be used to explain the nature of the coming together of two isolated experiences.

In Fig. 1, Experiences 1 and 2 are diagramatically repre-

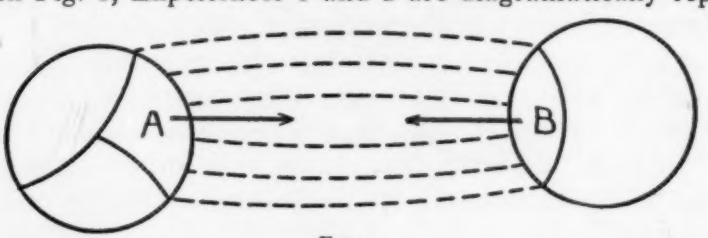

FIG. 1

sented. The essentials of each of these are designated by *A* and *B*. Let us say that *A* and *B* must be combined in order that the problem be solved. The field of strain then is the force which acts so as to bring them together.

From this it follows that there are two possible reasons

why *A* and *B* may not come together. (1) Parts *A* and *B* may be so embedded in Experiences 1 and 2 that they resist being broken away from the configuration of which they are a part. (2) The field of strain may not afford sufficient energy to pull them together.

A method for testing the first of these alternatives is as follows. If Experiences 1 and 2 form strong *gestalten*, then they should tend to remain unified wholes and the parts essential to the solution should be broken away only with difficulty. Hence experimental variation of the structure of the isolated experiences should vary the difficulty of the problem.

In my tests for ability *R* already referred to (11) the experiences involved are very simple, and the essential elements which form the solution are not strongly embedded in them. However, in the tests for $R - L$, the essential elements of one of the experiences was closely bound to other of its elements by means of a habit which had been established.

Thus in the test for *R*, *X*, *Y* and Z are tables joined together by elevated pathways which become familiar to the rat

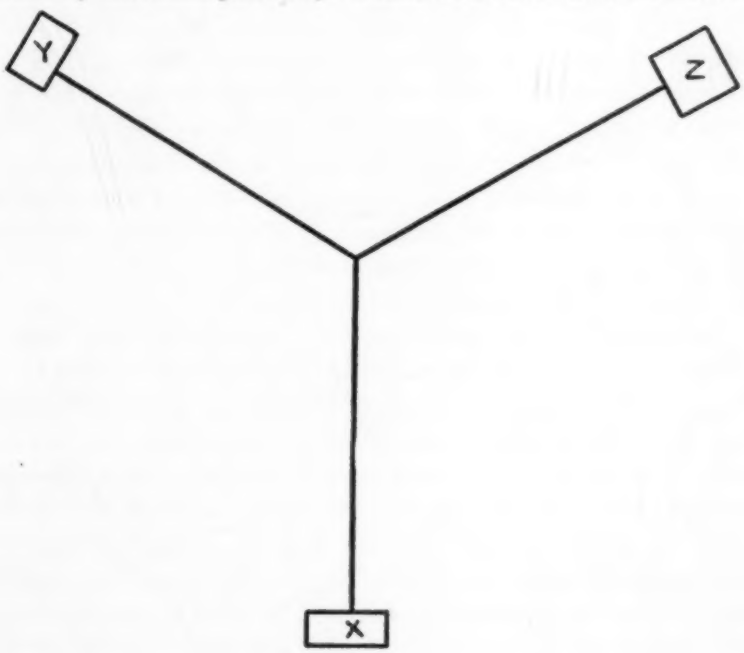

FIG. 2

during the period of exploration. (See Fig. 2.) This period of exploration gives the rat Experience 1. After the rat has become perfectly familiar with the situation it is removed from the pathways and fed on one of the tables (*e.g.*, *X*). The experience of receiving food on one of the tables gives the rat Experience 2. In the test the rat is placed on one of the other tables (*e.g.*, *Y*) and its choice of the remaining two tables observed. In order to reach the food directly, the rat must combine its knowledge of the pathways with the experience of feeding at a certain point. Thus part of Experience 1 must be combined with Experience 2. The rat must use the pathway leading from *Y* to *Z*, for example, and not use its experience of turning to table *Z* which is also part of Experience 1.

In the test for $R - L$, a habit was made part of Exper. 1. Thus the rat may be caused to run from table *Y* to *Z* for food. In this manner the experience of the pathway pattern was made to contain stronger bonds between the essentials and other parts of the experience. After being fed at *X* (Exper. 2) and started from table *Y*, it might be supposed that Table *Z* will be eliminated with difficulty because of *Z*'s association with *Y*. Consequently the essential of Exper. 1 (pathway leading from *Y* to *X*) will resist entering into the solution, if the first supposition is true. The results, however, showed that tests *R* and $R - L$ differed but little in difficulty.

Further, we might complicate Experiences 1 and 2 by increasing the number of elements, and thus perhaps increase the difficulty of separating out their essentials. This was the case in my original tests for reasoning (7).

By devising such a series of tests and presenting them to animals of varying degrees of ability (if necessary, animals of inferior ability could be created by means of cortical extirpation) we can measure the difficulty which arises because of inability to separate out the essential elements from the total experiences.

In the second possible alternative, a rat's failure depends on a field of strain which is too weak to bring the essentials of two isolated experiences together. If this alternative is a reality then the introduction of a strain which acts in the op-

posite direction should greatly increase the number of failures. In Fig. 3 such a condition is diagrammatically represented.

A method for introducing such an opposing force was suggested by one of my earlier experiments in which the starting point of a pathway was in one room, and the food-table to which it led was in an adjoining room. The rat was previously familiar with both rooms and thus had had Experience 1. In this experiment it was taught to run from the starting

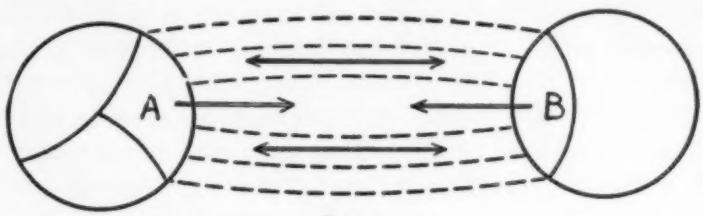

FIG. 3

point of the pathway in the one room to the food-table in the other. This run constituted Experiment 2. In the test the rat was started from the room which contained the food. (From the starting point the animal was able to smell the food, but was not able to reach it because of a wire cage. In order to reach the food the animal had to go to the pathway which was in the next room.) It was found that the rat had great difficulty with the problem because of its hesitancy to enter the next room. Leaving the room which contained the food was leaving the situation, yet this was necessary for the solution of the problem. If, however, the rat succeeded in entering the room with the pathway it went directly to the pathway. On the other hand, a rat which had not received Exper. 2 showed no hesitation at the doorway. It wandered freely about the two rooms and did not go to the pathway. It failed the problem and could therefore leave it with ease.

If this experiment is verified we have a method for introducing a force which is in opposition to the one which brings isolated experiences together.

The above exposition of problems thus clearly shows that the concept of a field of strain has definite consequences in that it raises behavior problems which can be subjected to

experimentation and at the same time are very different from problems which are suggested by other positions. Whether or not the concept has any virtue depends entirely upon the nature of future experimental results.

Summary

After an examination of the results of studies on rats and man it is found that reasoning and learning have definite characteristics which make them qualitatively different. Association by contiguity is inadequate for explaining reasoning both in rats and man. To explain the spontaneous combination of isolated experiences the concept of a field of strain has been postulated. The evidence for and the consequences of this concept are discussed in detail. It is found that the concept of a field of strain is in harmony with the results obtained from recent studies in physiology and neurology.

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[MS. received January 28, 1931]

THE PRIMARY FACTORS IN LEARNING

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The history of a scientific problem is seldom a straightforward development from description to functional interpretation. Interpretation is often proposed long before description is complete. This is a matter of necessity where it is difficult to ascertain the facts, or where the facts are so complex that they have to be put into some order by a functional interpretation. The danger of such a development is obvious. The premature functional interpretation of a complex set of facts may be so convincing that it becomes a hindrance to an exact description of the facts and consequently to an adequate interpretation. This has happened in the case of the problem of learning. The interpretation embodied in such functional concepts as 'formation of bonds,' 'nervous pathways,' and, worst of all, 'conditioning of responses' has prevented us by reason of their simplicity and seemingly wide applicability from seeing the facts of learning as they really are. An attempt is made here to present a necessary supplement to the usual description of learning and to indicate its relation to some specific problems of learning.

The purpose of this paper is to point out that every habit exhibits four well differentiated factors which should be considered separately whenever problems of learning are tested by experimentation and whenever experimental results are interpreted. The claim is made that these factors occur in all learning and that certain important conclusions will follow if we consistently distinguish between them. The four factors are: Tension, pattern of tasks, pattern of movements, and sensori-motor control. I shall first characterize these distinctions and then point out their application to some specific problems of learning. In doing so we are considering a special type of action. Much of our analysis will therefore be applicable to actions in general.

By tension is meant that condition of the psychological field which exists when the animal is ready to act and which persists until the final step of its action is consummated. As long as the psychological field contains a potentiality for action of a definite kind, tension may be said to exist in it. Special aspects of tension have been studied under such terms as motivation and drive. Of this factor of a habit I shall have little to say in this paper beyond emphasizing that it is the medium in which the other factors of a habit are imbedded, so to speak. We have evidence that the tasks and movements performed by an animal are not merely concatenated elements but depend for their appearance upon this ever present dynamic factor. This fact has always been known, especially to animal experimenters, but has only recently been studied systematically by Tolman and his students (**9**). Its unifying character, that is, its persistence if a habit is broken off in the middle of its performance, is indicated by the studies of Lewin and his students (**5**). It is probably the fundamental condition that accounts for the results of the delayed feeding experiments of Watson and others (**10**).

The pattern of tasks consists of the changes produced by the animal in the psychological field. It may have to approach a door and press down a lever; or it may have to grasp a small stick with which to reach for a larger one with which to obtain a banana. The function of the pattern of tasks is to relieve the tension in the psychological field. The pattern of tasks should not be confused with a certain aspect of the physical situation which is sometimes called pattern too, namely the spatial arrangement of objects. This physical pattern may be called a lay-out. Thus we have in card sorting a certain lay-out of the card containers and in typewriting a lay-out of the keys. The pattern of tasks in the case of card sorting is determined by the cards as they are turned up and by the lay-out of the card container.[1]

[1] I wish to emphasize that I am making a psychological analysis by means of objective concepts. As an outside observer I am concerned with the behavior of animals in a field of stresses and forces, the 'psychological field.' What happens to the extra-organic aspects of this field is just as important for my description of the process studied as what happens to the intra-organic aspects. Employing the term

The pattern of movements consists of the muscular and sensory processes by which the animal accomplishes the pattern of tasks. It moves its legs guided by visual and kinesthetic sensations, it raises its paws, opens its jaws, etc.

The sensori-motor control consists of the accuracy, speed and energy of the muscular and sensory processes; it provides the aspect of efficiency in the performance of a habit. In this sense sensori-motor control may be called a tool of the pattern of movements, just as this may be called a tool of the pattern of tasks. If the pattern of tasks consists in the joining of two sticks, this may be done clumsily or skillfully; there may be little or much sensori-motor control.

Although all four factors are always present in a habit, their relative preponderance varies. There are habits in which sensori-motor control is the predominant factor as in ball tossing, mirror writing, and shooting with bow and arrow. The pattern of movements is the predominant factor in such habits as dancing and vocalizing. The pattern of tasks is the predominant factor in such habits as tracing a maze and going through a puzzle box.

The question whether or not different abilities are involved in the performance of the pattern of tasks, pattern of movements and sensori-motor control can be investigated by correlating habits in which these factors predominate. This is not, of course, the problem of the relation of 'motor' habits to 'ideational' habits. Thus, both maze tracing and mirror writing are 'motor' habits, but each has a different factor predominating.

The value of any such distinction as that of the four primary factors of a habit depends on its ability to make significant facts stand out. This will now become apparent when we take up the application of these distinctions to the problems of uniformity, insight, trial and error, frequency, imitation, and the neurological mechanism in learning.

'task' I am referring to changes in the psychological field that are largely extra-organic. Employing the term 'tension' I am referring to the condition that exists when the equilibrium in the psychological field has been disturbed so that changes are bound to occur. In neither case am I concerned with assumed conscious aspects of the animals experience.

1. *Uniformity of action.*—The concept of habit contains many assumptions. One of the foremost of these is uniformity of action and sometimes more specifically uniformity of movements. Until very recently discussions of the laws of learning and of the neurological basis of habits implied this concept of uniformity as if it were an observed fact. The following analysis will show that uniformity is by no means the rule in habits and that we may have uniformity in one factor and variability in another.

In respect to patterns of tasks we have two distinct sets of conditions according to whether we are dealing with repetitive or non-repetitive patterns. In the former there exists uniformity as in maze tracing and going through a puzzle box, while in the other there is a constant change in the pattern as in typewriting, card sorting, and piano playing.

In patterns of movements uniformity is very exceptional. The plasticity of movements which we find here is dependent on the relationship between the pattern of movements and the pattern of tasks. *Since the pattern of movements is the tool of the pattern of tasks it need not necessarily be the same in the successive performances of the habit, as long as the same tasks are accomplished.* This means that there are many habits that permit the use of one set of movements at one time and of another set at another time; even where the pattern of tasks has become stereotyped the pattern of movements will remain plastic. After an animal has learned to open a door with a lever, its pattern of movements may show a considerable plasticity even after a large number of trials: It may use its left paw at one time, the right paw at another, and its teeth or nose at still other times, so that we may be forced to conclude that *each trial represents a fresh muscular adjustment to the pattern of tasks* (7, 8). It is such observations that force us to distinguish between pattern of tasks and pattern of movements. There are also habits that require uniform patterns of movements, such as dancing and shooting with bow and arrow. In habits where there is an irregular sequence of a limited number of tasks, as in typewriting and card sorting, we naturally have an irregular sequence of movements

which themselves may be uniform, however, for the same tasks.

In sensori-motor control again, variability is the rule and uniformity is almost entirely absent, although in certain skills such uniformity is approached. Ordinarily the efficiency of even the same movements varies from trial to trial.

The nature of variability is different in each factor. The non-uniformity of a non-repetitive pattern of tasks has nothing in common with the plasticity of a pattern of movements or the variability of sensori-motor control. The latter is probably determined to a large extent by intra-organic elements in the situation, such as tonus, fatigue, emotional states, and previous practice. On the other hand, I am at a loss to suggest how the plasticity of movements is determined.[2]

2. *Insight in the fixated habit.*—A highly important distinction relative to patterns of tasks is that between rational and arbitrary ones. A rational pattern of tasks is one in which the relationship between the successive tasks may be, but need not necessarily be, reacted to as a functional or causal sequence. Shooting with bow and arrow and running through a puzzle box are examples of rational patterns. An arbitrary pattern of tasks is one in which the relationship between the successive tasks can only be reacted to as a temporal sequence. Card sorting and maze tracing are examples of arbitrary patterns.

It will be seen immediately that the same rational pattern of tasks may be reacted to by one animal as a rational pattern and by another as an arbitrary pattern. Distinguishing be-

[2] It is sometimes suggested by psychologists who insist on the principle of uniformity of habits that the lack of uniformity of movements is due to the difference in the stimulating situation from trial to trial and that if we only had similar stimuli we would get the same movements as demanded by the nerve path theory. Such a position, in the first place, amounts to an admission of plasticity. In the second place, plasticity of movements means the change of gross muscular coördinations (e.g., right to left paw) that would be difficult to reconcile with the slight changes in the stimulating situation that are supposed to impress variations on the already established nerve paths. And in the third place, such a position does not agree with the observed facts of equivalent stimuli and equivalent movements. In an unpublished study the writer observed that the angle of approach to a lever or the nearness of approach had nothing to do with an animal's use of the right or left paw in order to manipulate it.

tween the two types of insight displayed here we may also say that the first animal shows *functional insight* and the second *cumulative insight.* A human being in a puzzle box may exhibit functional insight, that is, he may recognize the essentially functional relationship of manipulating the fastenings and releasing the door. However, we may also train an animal to perform the same tasks without its grasping their functional significance, except that one must succeed another: it is displaying cumulative insight.

3. *Insight during acquisition of habits.*—The two types of insight existing in fixated patterns of tasks also play a role in the acquisition of such patterns. Which type will be used depends upon three things: The nature of the situation, the general ability of the animal, and its past experience. The use of cumulative insight involves either the method of trial and error or that of guidance. The use of functional insight involves a third method distinct from these two.

A rational pattern of tasks may be learned either by functional insight or the methods of cumulative insight. Solving a mechanical puzzle may be done by grasping the functional relationships of the parts and the steps; or by manipulating it and trying this and that combination, finally hitting on the right one; or by suggestions from a tutor; or by a combination of these methods. The use of cumulative insight in the acquisition of a rational pattern of tasks does not, however, preclude the possibility that in the fixated habit cumulative insight will be replaced by functional insight. Even after one has learned a mechanical puzzle by chance one may achieve functional insight in regard to it. It may be possible to ascertain the type of insight existing in the fixated habit by objective criteria just as the type of insight used during acquisition has been ascertained by such criteria (3).

An arbitrary pattern of tasks can be learned only by cumulative insight, that is, by the methods of trial and error or guidance. When put into a maze an animal can find out only by trial and error or guidance which alleys are to be avoided and which are to be entered. There are some experimental situations like the maze and the visual discrimination box

that can be learned either by trial and error or by guidance; and there are others like card sorting, writing, and dancing that can be learned by guidance only. In the case of card sorting guidance is accomplished by the similarity of symbols printed on the cards and the containers.

Certain special situations, e.g. those involving spatial relations, that require trial and error or guidance during the early stages of learning may permit a certain measure of functional insight during the later stages. After a maze has been partially learned by trial and error an element of functional insight into the spatial relationships may appear. It may even happen that an arbitrarily constructed spatial relationship will present to one animal the possibility of a rational pattern of tasks in case it has already learned its constituent parts separately, while it will present an arbitrary pattern of tasks to another animal that has had no experience with any of its parts. This has recently been demonstrated by Maier in a series of ingenious experiments with white rats (**6**).

If we consider the acquisition of patterns of tasks a matter of intelligence we are led to assume two kinds of intelligence. There is the kind which grasps functional relationships and the kind which fixates temporal sequences. The two kinds are not mutually exclusive; both may be, and often are, present in the same habit. The relation between the two constitutes a fundamental problem in learning.

4. *Two types of trial and error.*—So far we have considered trial and error only in regard to the acquisition of an arbitrary pattern of tasks. In the acquisition of sensori-motor control we also have what may be called trial and error. In ball tossing and writing we also try and fail, but this is an entirely different kind of trial and error from the one encountered in maze tracing. We must therefore distinguish between the trial and error method in learning an arbitrary pattern of tasks and the trial and error process in the acquisition of sensori-motor control.

5. *The law of frequency* in habituation has been both asserted and denied on the basis of seemingly conflicting experimental material. The proposed distinction between the four

factors of learning enables us partly to clarify this contradiction.

Sensori-motor control is acquired by repetition and no other way. Consequently, habits in which sensori-motor control predominates will strictly exhibit the law of frequency.

Patterns of movements that are plastic are unaffected by the law of frequency since they consist of muscular adjustments that are produced anew in each trial.

Patterns of movements that are uniform exhibit the law of frequency.

Patterns of tasks present a more complicated case in which the function of frequency differs radically from the preceding cases. When simple, a rational pattern of tasks may be acquired before any actual trial has taken place, while for an arbitrary pattern of tasks at best one trial is required for acquisition. Beyond this, frequency is a function of the complexity of the total patterns: the more complex the pattern, the more repetitions are needed for fixation. Parts of the patterns may, however, at any time be dropped or acquired uninfluenced by frequency since they may occur as simple units and as such be subject to the conditions stated above. We thus have the paradoxical situation that for the acquisition of a fairly complex pattern of tasks the law of frequency holds, while it need not hold for its constituent parts. A complex maze can only be learned by many repetitions while the entry of alleys is not determined by frequency.

Once a pattern of tasks is established, frequency operates in creating a greater assuredness and mechanization in the succession of tasks, an aspect of learning to be distinguished from mere smoothness of movements, which is a matter of sensori-motor control. This mechanization sometimes appears as a unification of groups of tasks so that in the end a hierarchy of tasks is created, as in language and musical habits.

6. *Elimination of errors.*—If a pattern of tasks is learned by trial and error and consequently by frequency, the difficult question arises of how errors are eliminated. Taking maze tracing as an example of an arbitrary pattern, we may say that the elimination of a wrong turn is the reverse of the in-

corporation of the correct turn as a minor unit task into the total pattern of tasks and as such may take place without reference to the law of frequency as just described.

However, it may happen that the wrong turn in a maze temporarily becomes a definite task. Repetition is then needed to establish the incorrectness of the task in relation to the whole pattern. Or it may happen that in a similar way an error is incorporated in a larger unit in a hierarchy of tasks so that it becomes mechanized within the larger unit. A word may be persistently misspelled in typewriting, or a wrong note be persistently played on the piano. In such a case the intentional practising of the wrong task seems to assist the elimination of the error as has recently been pointed out (1). This paradoxical effect is perhaps due to the *intentional* nature of the repeated practice whereby the *mechanized* performance is brought down to its former level in which the larger unit of tasks is again disintegrated into its individual tasks. Since the error is intentionally practiced as the wrong task, it is thereby set off against the correct task so that one may be substituted for the other as in the acquisition of a simple task described above. Practice is then again needed until the correct task has reached the mechanized level.

7. *Imitation.*—The problem of imitation is usually conceived in terms of reduplicated movements. But what we really have in the few cases where imitation has actually been observed in animals (3) is *reduplication of the pattern of tasks, provided the proper tension occurs* in the psychological field of the imitating animal. If one chimpanzee imitates another by grasping a straw and poking in a hole in the wall, he is doing so because in perceiving the psychological field of the first animal a similar field was created for him, so that a similar pattern of tasks is bound to be performed by him. Such a pattern of tasks permits plasticity of movements as stated above, so that we need not expect reduplication of movements. It seems that the observed facts of imitation alone would force us to make some such distinction as that of the four primary factors in learning.

There is one case of imitation that does not seem to fit

into the suggested explanation: the imitation of vocalization by children and some birds. It is possible, and even probable in the case of children, that we are dealing here also with a reduplication of tasks upon the occurrence of the proper tension, although superficially the facts indicate a reduplication of movements, especially in the case of birds.

8. *Neural mechanisms.*—It is with great hesitation that I approach the problem of the neurological mechanism of habits. At best, the psychological description of the learning process can only be suggestive of the type of neural mechanism we may expect to find. Its value perhaps lies in suggesting that since the learning process consists of different factors, the neurological mechanism too may consist of different types of processes; that *considering the essential difference between the constituent factors of habits one might expect to find somewhat similar differences between the types of neural mechanisms involved.*

The dynamic factors, tension and pattern of tasks, would suggest a type of neural mechanism that is also dynamic in character as pointed out by Köhler (**2**). The absence of localization and the existence of unity of action of the partially destroyed cortex in the maze habit of white rats as found by Lashley (**4**) would seem to harmonize with our characterization of this habit as one in which the pattern of tasks is the predominant factor and the pattern of movements is essentially plastic.

The sensori-muscular factors, pattern of movements and sensori-motor control, would suggest a *temporary neural organization* during any particular performance of a habit as long as plasticity of movements and ordinary efficiency of control, not depending on special training, are possible. By no means could we expect here a permanent spatial arrangement of neurons with worn down synaptic resistances as demanded by the usual neural theories of learning. Localization would seem probable, however, wherever we have a uniform pattern of movements or a high sensory efficiency in a specific sensory field or a high muscular efficiency in a specific muscular group produced by special training.

To summarize, it has been maintained that a habit consists

of four primary factors, tension, pattern of tasks, pattern of movements, and sensori-motor control. The last three show different degrees of preponderance so that a certain habit may be characterized accordingly. It has also been shown that this distinction between four primary factors helps to elucidate specific problems of learning. Uniformity in habitual acts is in most cases a matter of stereotyped patterns of tasks while the patterns of movements may remain plastic. Sensori-motor control approaches, and probably never attains, uniformity. The concept of insight refers only to the patterns of tasks which are either rational or arbitrary and consequently require functional or cumulative insight respectively. A rational pattern of tasks may be learned by functional or cumulative insight; if learned by the latter type the result may yet be functional insight. An arbitrary pattern of tasks can be learned only by cumulative insight through chance or guidance. There are two types of trial and error, one occurring during the acqusition of an arbitrary pattern of tasks and the other during the acquisition of sensori-motor control. Frequency is an essential condition only in sensori-motor control, uniform patterns of movements, and arbitrary patterns of tasks. Imitation in animals seems to be a reduplication of patterns of tasks and not a reduplication of patterns of movements. As regards neural mechanisms it is suggested that the psychological differences between the primary factors imply comparable physiological differences between those mechanisms. Wherever plasticity of patterns of movements exists a temporary neural organization during the performance of the habit seems to be the only possible assumption.

In conclusion we may again call attention to the fact that the so-called problems of learning do not as a rule concern the whole learning process as it is sometimes assumed, but only some primary factor. Generalizations should therefore be made not in regard to habit formation as a whole but only in regard to that primary factor of learning which the particular experimental situation is capable of testing.

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[MS. received December 5, 1930.]

THE LOGIC OF GESTALT PSYCHOLOGY

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If there is any tendency at the present time common to or running through all the sciences, it is the increasing interest manifested in the examination of the logical foundations and method of procedure of science. It requires no argument to show that this interest is prevalent in the physical sciences, for the physical theory of relativity is itself an illustration of the truth of the statement. Among biologists this same interest exhibits itself in the doctrine of *emergence*, for, from the methodological point of view, the theory of emergent evolution is but another name for the idea that there are limits to the scientist's powers of explanation. Another example of this is presented by Prof. J. H. Woodger,[1] who argues that before the biologist can hope to solve his problems he must develop a logical technique adequate to handle the biological problem of 'organization.'

Among psychologists, however, the truth of the above statement is not so obvious. American psychologists have exhibited little interest in the logic of psychology, at least as compared with Continental psychologists. To be sure, the behaviorists have shown considerable logical acuteness in criticising the assumptions and the logic of other systems of psychology, but they have failed to exhibit the same acumen in criticising their own reasoning—this, perhaps, because they do not believe in introspection.

If one peruses current textbooks of psychology with the aim of gaining some insight into the nature of thought, it will probably be discovered that one of the least profitable chapters in these books is that devoted to the subject of 'Reasoning.' The material there presented is integrated with neither

[1] J. H. Woodger, The 'concept of organism' and the relation between embryology and genetics, part ii, *Quart. Rev. Biol.*, 1930, 4, 438–463.

of the bordering sciences of physiology or logic. This is all the more surprising since the psychologist himself aims to function as a reasoning creature when, as a scientist, he works out a 'system' of psychology which attempts to explain human conduct. Many a psychologist apparently fails to realize that his psychological explanation of thinking must be applicable to his own doctrines, as illustrations of thought. The writer [2] pointed this out in an earlier article in the statement: "Any account of thinking, whether by a Behaviorist or an Intellectualist, which ignores these [logical] processes or fails to explain them stands condemned at the outset, for it is through the use of these logical operations that any system of psychology can hope to establish itself." These lines are equally applicable to behaviorism, psychoanalysis and gestalt psychology. Elsewhere [3] the writer has pointed out the ways in which Freudian psychology and behaviorism fail to meet this test. The way in which gestalt psychology falls short of this requirement is the concern of the present paper. However, the interest of the present paper is not negative, for it is written under the conviction that of the three systems just mentioned gestalt theory holds out the greatest promise of being developed into a system which can explain itself in terms of its own configurational principles. In another paper [4] the writer has called attention to the possibility that the logical processes of reasoning whereby we solve problems (through the use of 'insight') exhibits a 'closure' similar to that of an instinct, and that logical necessity in inference may be analogous to the 'snapping into form' which the gestalters claim is evident in perceptual processes. The gestalters have made much of the notion of insight, but, unfortunately, this idea has become enveloped with a kind of mysticism. It appears to me that *insight* is only another name for a process which has long been familiar to us. But before considering this let us deal briefly with the general nature of the *gestalt*.

One of the properties of a gestalt is said to consist in the

[2] O. L. Reiser, The structure of thought, PSYCHOL. REV., 1924, 31, 51–73.

[3] O. L. Reiser, Humanistic logic, T. Y. Crowell Co., 1930, pp. 118 and 92.

[4] O. L. Reiser, Gestalt psychology and the philosophy of nature, *Phil. Rev.*, 1930, 34, 556–572.

fact that as a *whole* its properties are something more than the summation of the properties of the constituent *parts*. Thus, for instance, the distribution of electricity in a conductor is not an additive resultant of single charges. A second property of a gestalt consists in the fact that it can be *transposed*. A gestalt is like a melody in that it can be played in different 'keys.' The constancy of the melody is due to the relation between the different notes. And here is where 'insight' enters.

A 'problem' presents itself as an open gestalt, which 'yearns' for solution, and it is the function of thought to find the solution by transforming the open gestalt into a closed one. From this point of view, an intelligent person is one who is able to transpose one situation into another. For purposes of illustration let us consider one of Professor Köhler's examples. In order to subject certain deep-lying organs in the body, known to be cancerous, to X-ray treatment, it is necessary to increase the penetrative power and amount of radiation beyond that required for the treatment of superficial tissue; but to do this increases the harmful effects of the radiation on the intermediate tissue. The problem is, therefore, how to get the proper dosage to the underlying organ without injuring the overlying tissue. A person's intelligence may be measured by the time it takes him to find the solution to this problem. The problem is solved, of course, by going at the organ from different directions; that is, the cancerous organ is made the common focus of different pencils of radiation from several different directions, which then gets the benefit of the total radiation without the overlying tissue being subjected to excessive amounts of radiation. Now some persons (those who are not 'imageless thought' reasoners) may think of this solution by analogy to a wagon wheel, the spokes of which, proceeding from different points at the periphery, meet in the center at the hub. But in any case one has to fall back upon his past experience and *transpose* some relevant situation into that presented by the problem. But as thus stated, this is nothing more than *reasoning by analogy*. Indeed, it may well be argued that the entire system of gestalt psychol-

ogy rests upon analogies between the properties of phenomenal (conscious) patterns and the underlying physico-chemical patterns supposed to exist in the nervous system.

In identifying 'insight' with reasoning by analogy we have no desire to detract from the value of this view of intelligence. Our purpose is merely to remove the element of occultism from the process and to suggest that after all the idea is not so very original. As thus stated, insight still retains its validity as one test of intelligence, for reasoning by analogy is probably the most important method whereby science secures new hypotheses to explain established facts. That this is the case may be seen when we put analogy into the form of a proportion, as follows:

$$\frac{A}{B} = \frac{C}{D} \text{ or } 2 : 4 : : 8 : 16$$

In the concrete case of solving a problem, of reacting to a new situation in terms of previous experience, we have:

New problem : *old problem* : : *new solution* : *old solution*

By substituting numbers for the elements of the ratio, and observing the principle that the product of the means is equal to the product of the extremes, these proportions can be stated in different ways. It must be recognized that the two things or situations which are compared are usually complex, each consisting of an assemblage of properties. Probably no two things in nature (not even two electrons) are ever exactly alike in all respects, but the relatively insignificant differences among objects of the same class can be ignored. 'Identity' is really the limiting case of analogy as two things become more and more alike. The comparison of the elements of an analogy presupposes a process of 'matching,' and if, as the matching proceeds, it becomes evident that the assemblage of properties of the new situation corresponds point for point with the assemblage of properties of the old situation *in significant respects*, the analogy increases in validity or probable truth. Theoretically we never reach absolute certainty in this type of reasoning, but, at best, secure a high degree of probability.

As an illustration of an analogy which may turn out to be defective, consider the process by which the notion of an ether of space was assumed to be the medium for the transmission of light rays. The proportion is this:

Ether waves : *ether* : : *water waves* : *water*

But physicists, partly as a result of the verification of the theory of relativity, are now considering the possibility that there may be 'waves' (e.g., light waves, *psi* waves) without there being something (a medium) in which these waves occur. Physicists have probably not revealed to the public the full extent to which their science is thrown into chaos (so far as theory is concerned) by the new results in micro-physics. That science is indeed reduced to a state of theoretical ignorance is obvious from the following. Physicists tell us that the general differential equation for the steady flow of heat, light, electric waves, and magnetism, where a is the velocity of transmission, is as follows:

$$\frac{\partial^2 y}{\partial t} - a^2 \frac{\partial^2 y}{\partial x^2} = 0$$

In these cases, when the properties of the given differential equation are developed, the results are applicable in each of these fields. All these phenomena are treated as analogous in certain significant respects. The assumption is made that a mathematics of continuity (the infinitesimal calculus) is applicable, presumably because you suppose that you have to do with a continuous distribution of energy spreading out from the source. But if we take away the medium which provided the continuity, and which made the application of differential equations valid, there arises the question of whether all such physical processes ought not to be dealt with by some other type of mathematics, a mathematics of discontinuous units and processes.

Science proceeds on the principle that to explain a phenomenon is to exhibit the new process as a special illustration of an older and more familiar process, or law of behavior. Thus the biochemist hopes to understand the phenomena of

life by finding in inorganic systems phenomena which are analogous to the properties of living systems. But, as previously intimated, there seems to be an increasing willingness to consider the possibility that the old, the already familiar, is not always adequate to explain the new, the unfamiliar. If the theory of emergent evolution be correct, certain phenomena may be *sui generis*. Perhaps the phenomena of consciousness have no parallels in physical processes. Gestalt psychology (as Professor Köhler once admitted to the writer) has much in common with the doctrine of emergence, and yet it is difficult to see how there can be any 'emergence' of gestalten in 'organic' systems if physiological and phenomenal patterns are only special cases of physical gestalten. The gestalters have never made their views clear on this matter.

If, at this juncture in physical science, the gestalters take their cue from the procedure of the physicists, they will follow up a different type of analogy ('insight'). In the new quantum mechanics physicists are resorting to a mathematics of multidimensional space to 'explain' certain physical phenomena. In the new wave mechanics as many as ten dimensions may be introduced. In this case the physicist's understanding of the properties of each next 'higher' dimension is obtained by reasoning from the properties of 3-dimensional space as compared with the properties of 2-dimensional space, and so on. That is:

$$\frac{\textit{4-dimensional space}}{\textit{3-dimensional space}} = \frac{\textit{3-dimensional space}}{\textit{2-dimensional space}} = \frac{\textit{2-dimensional space}}{\textit{1-dimensional space}}$$

The fact that time always plays the rôle of the next highest dimension [5] is suggestive when taken in connection with the view of Dr. S. Alexander [6] that *time is the mind of space*. The possibilities for developing this idea of psychism as a new dimension, supplementary to the recognized coördinates of

[5] J. H. Jeans, The mysterious universe, 1930, p. 129.

[6] S. Alexander, Space, time, and deity, 1920, vol. 2, p. 38.

space, have been recognized by T. B. Robertson,[7] A. P. Mathews,[8] and W. P. Montague,[9] all of whom have played with the idea that psychic phenomena represent an additional dimension intersecting the spatial coördinates of the physical universe. This is not the place, however, to develop the implications of this type of explanation. What I am concerned to point out is that, stated in its present form, gestalt theory is inadequate to explain reasoning in terms of the physical analogies now employed. The attempt to explain the closure of a gestalt by appealing to the principle of 'minimal configurative energy' is quite satisfactory so far as simple perceptual processes are concerned (e.g., in the tendency of the visual after image of a square to change into a circle), but as an explanation of complex conceptual processes this idea will not be sufficient. Thinking at its best, as in mathematics, cannot be deduced from any known principles of physiology. The 'neatness' which characterizes a perfect postulate-set is not the simplicity and compactness of structure of a perceptual pattern, as the writer once pointed out.

What is needed, I think, is for the gestalters to develop further the physiological implications of the theory of psychological relativity. Let us expand this suggestion. It was pointed out that in the case of a melody, which can be transposed, the gestalt consists in the *relation* between the notes in the temporal sequence. But we must not think of the 'notes' (*i.e.*, the elements of any phenomenal pattern) as being invariably localized in any specified set of neural elements. To indicate the type of cerebral function underlying the gestalt, let us consider the possibilities.

In any psychological theory where the reality of conscious experience is admitted as a datum there are only two ways in which these conscious processes can be correlated with the accompanying physiological processes. The relation between consciousness and the bodily process is either (*a*) a

[7] T. B. Robertson, Consciousness and the sense of time, *Scient. Mo.*, June, 1923.

[8] A. P. Mathews, The reduction of all physical dimensions to those of space and time, *J. Wash. Acad. Sci.*, 1923, 195–210.

[9] W. P. Montague, Time and the fourth dimension, *U. Calif. Pub. in Philos.*, 1925, 7, 183–207.

one-to-one (or univocal) relation, or (*b*) a one-many (or non-univocal) relation. That is to say, taking for example the case of the experience of *redness*, whenever we have a particular experience of the color red the relation of this experience to the physiological process is such that either (*a*) on successive occasions of the perception of red the *same* bodily process always underlies the *same* conscious process, or (*b*) on successive occasions when we perceive this particular red a *different* bodily process may underlie the *same* conscious process. In the first case, (*a*), the correlation is one-to-one; in the second case, (*b*), the correlation is one-many.

Undoubtedly psychologists have for the most part tended to assume that the first type of correlation held in human beings. They still talk of this set of neurones doing one thing and that set of neurones doing something else. But as Professor Bartley informs me, results indicate [10] that the same cortical tissue may be both active and passive at the same time. Cerebral action currents are such only by virtue of a difference in potential at two points at a given time. Whether such a current will appear depends upon where one electrode on the brain is with respect to the other. This fact, which seems to support our second alternative, (*b*), (*i.e.*, that any 'element' gets its character from its *relation* to other elements of the gestalt and that this relation, since it can be transposed, can arise out of the activity of different structural complexes) has been summarised in different words by Dr. K. S. Lashley, when he refers to patterns (dynamic) shifting about over nervous structure much as an electric sign over a bank of lights.

Such a view does not imply the denial of the possibility of a science of psychology, though it makes the problems of psychology much more difficult. The value of the view is that it frees the theorizer from the poverty-stricken physiology of the past, and thus makes it possible to find a *functional* complexity of brain patterns which can parallel all the complexity of reasoning in its most abstruse flights. Moreover, in the

[10] S. H. Bartley and E. B. Newman, Recording cerebral action currents, *Science*, 1930, 71, p. 587.

distinction between the 'figure' and the 'ground,' interpreted in terms of physiological relativity, we have the beginnings of the doctrine of the movement of thought through the union of opposites into higher intellectual syntheses. As a result of the interaction between an organism and its environment, and between the different, relatively isolated, systems (gestalten) within the organism, a set of relations appears which cannot be explained in terms of either pole of the duality taken by itself. Thus we are introduced to the concept of *transcendence*, which, as Dr. R. M. Ogden has pointed out, is really necessary to complete the system of gestalt psychology.

According to this view, each whole is a relative whole, being always a pattern within a larger whole, actual or possible. In our thinking we always reach out to the superior class or the larger generalization with reference to which each inferior class or generalization secures its relative properties or meaning. In this respect reasoning is the cerebral counterpart of the general biological differentiation of part patterns within larger wholes (this latter being demonstrated by G. E. Coghill's work), while evolution, on the other hand, is the phylogenetic counterpart of the self-transcendence evident in thinking as it moves on to new integrations of responses. Logicians break up the process of inference into deductive reasoning and inductive reasoning, but actual reasoning always contains an element of both, and these can be isolated from each other only through a process of abstraction. In thinking, as in biological evolution and individual development, analysis (differentiation) and synthesis (integration) are complementary and mutually implicative.

Summary

Of the various systems of psychology now in existence gestalt psychology holds out the greatest promise of meeting the test that it must be able to explain itself, as an illustration of thought, in terms of its own account of thinking. Gestalt theory, however, will have to be modified, if it is to do justice to such thinking as that of the mathematician. One possible

modification lies in a further development of the notion of physiological relativity (of cerebral action currents, etc.), which then provides a basis for the functional complexity of conceptual processes.

[MS. received January 2, 1931.]

WHY NOT RE-CHRISTEN THE 'PSYCHO-GALVANIC REFLEX'?

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The great amount of work done on the so-called 'psycho-galvanic reflex' has at least clearly shown that the original term applied is inadequate. Investigators using different techniques, get varying results, and yet often describe their findings in terms of the p.g.r. It is needless to say that ambiguity of terminology has perhaps led to more psychological controversies than anything else. A careful use of terms in describing phenomena, which can be distinguished on the basis of physical characteristics, may lead to a better understanding and closer agreement of experimental results.

It is quite likely that many of the studies of the electrical phenomena of the skin are directly comparable, but few papers have been published which definitely show that this is true. Jeffries (1928), as an exception, has measured changes in body resistance and found it to correlate highly with parallel measurements of the potential difference of non-adjacent skin areas.

In the present paper, a study of over three hundred titles reveals great diversity in nomenclature. In only about 60 percent of the cases was the distinguishing term definitely given. In 21 percent of the cases the nature of the phenomena measured was indicated in the title. Of course the papers themselves have been more explicit but often confusion exists as to the exact nature of the measurements whereby the reflex was obtained.

The following tables will show to some extent the results obtained from 183 out of 305 titles on the electrical phenomena of the body. Only unique designations are included. This means that some authors wrote several articles using the same

nomenclature, others used no definitely descriptive terms, and still others used different terminologies in different papers. Not all references are made to the same type of measurement but all have to do with electrical phenomena of organic tissues.

There is possibly some overlapping in the above list which could be still further reduced. It illustrates however the loose terminology in common use.

In general French writers have written more on resistance while the Germans have contributed largely in the field of conductivity, electric potential, capacity and polarization.

Table I

Common Nomenclature of Electrical Phenomena of Organisms as Has Appeared in Titles of English, French, German and Italian Scientific Periodicals

Term	Periodical						
	American	British	French	German	Italian	Other	Total
1. Autonomic reflex	0	0	0	1	0	0	1
2. Bio-electric current* of the skin	0	0	0	1	0	0	1
3. Capacity effects	0	0	0	2	0	0	2
4. Conditioned psycho-galvanic reflex	1	0	0	0	0	0	1
5. Electrical changes	1	1	1	0	0	0	3
6. Electrical characteristics	0	0	0	1	0	0	1
7. Electrical conductivity	0	1	1	7	1	1	11
8. Electrical expression	0	1	0	0	0	0	1
9. Electrical phenomena	1	1	0	0	0	0	2
10. Electromotive phenomena	0	1	0	3	0	0	4
11. Electrical processes	1	0	0	2	0	0	3
12. Electrical resistance of the skin	1	3	3	6	0	0	13
13. Electrical resistance of the body	1	0	7	1	1	0	10
14. Electrical state of the body	0	1	0	1	0	0	2
15. Electrical potential	0	0	1	7	0	0	8
16. Electrical signs of the human body	0	1	0	0	0	0	1
17. Electrical skin phenomena	0	0	0	1	0	0	1
18. Electromotive properties of the skin	0	0	0	1	0	0	1
19. Electroendosmose of the skin	0	0	0	1	0	0	1
20. Electrophores of the skin	0	0	0	1	0	0	1
21. Electro-physiology of the skin	0	0	0	1	0	0	1
22. Electro-physiology	0	1	0	0	0	0	1
23. Emotive response	0	1	0	0	0	0	1
24. Galvanic deflections	3	0	0	0	0	0	3
25. Galvanic phenomena	5	0	0	1	0	0	6

*Hyphens have been used as most commonly found. No uniformity exists.

TABLE I—*Continued.*

Term	Periodical						
	American	British	French	German	Italian	Other	Total
26. Galvanic psycho-physical reflex.....o	o	o	o	1	o	o	1
27. Galvanic reactions.....	1	o	o	o	o	o	1
28. Galvanic reflex.....	o	o	o	1	o	o	1
29. Galvanic skin reflex.....	1	o	o	5	o	o	6
30. Galvanimus.....	o	o	o	1	o	o	1
31. Galvano-psychic reflex.....	o	o	1	o	o	o	1
32. Neuro-galvanic reflex.....	o	o	o	o	o	1	1
33. Physio-galvanic variations....	o	o	1	o	o	o	1
34. Physico-psycho-galvanic reflex	1	o	o	o	o	o	1
35. Polarization.....	o	1	2	6	o	o	9
36. Psycho-electrical phenomena..	o	o	2	1	o	o	3
37. Psycho-electro-tacho-gram....	1	o	o	o	o	o	1
38. Psycho-galvanic phenomenon.	2	4	2	9	o	o	17
39. Psycho-galvanic reaction.....	o	2	o	3	o	o	5
40. Psycho-galvanic reflex phenomenon.....	o	o	o	10	o	1	11
41. Psycho-galvanic reflex.....	4	6	6	12	o	1	29
42. Psycho-galvanic variations....	1	o	o	o	o	o	1
43. Psychogalvanism	1	1	o	1	o	o	3
44. Psycho-galvano-metric (measurements).....	o	o	1	o	o	o	1
45. Secondary electromotive characteristics.....	o	o	o	2	o	o	2
46. Skin constriction reflex.....	1	o	o	o	o	o	1
47. Skin currents.....	o	1	o	o	o	o	1
48. Skin electricity.....	o	o	o	1	o	o	1
49. Skin magnetism.....	o	o	o	1	o	o	1
50. Skin potential.....	1	o	o	o	o	o	1
51. So-called galvanic reflex.....	o	1	o	o	o	o	1
52. So-called galvanic skin electricity.....	o	o	o	1	o	o	1
53. So-called polarization changes.	o	o	o	1	o	o	1
54. Vital magnetism.....	o	o	1	o	o	o	1
Totals.....	28	28	29	94	2	4	185

British writers have made contributions largely in method and studies of polarization. Americans have been more interested in applications of the phenomena. The most complete reviews have appeared under British and American titles. For this reason perhaps there is a tendency among the latter writers to use general terms. Some very excellent criticisms have appeared in English which are however directly the reverse of this tendency.

It seems quite important to standardize the terminology and to describe results in their simplest terms. To confuse

TABLE II

THE 12 MOST FREQUENTLY USED TERMS APPEARING IN ALL LANGUAGES

Term	Number	Percentage of all terms used
1. Psycho-galvanic reflex	29	15.70
2. Psycho-galvanic phenomenon	17	9.20
3. Electrical resistance of the skin	13	7.00
4. Electrical conductivity	11	5.95
5. Psycho-galvanic reflex phenomenon	11	5.95
6. Electrical resistance of the body	10	5.42
7. Polarization	9	4.90
8. Electrical potential	8	4.30
9. Galvanic phenomena	6	3.25
10. Galvanic skin reflex	6	3.25
11. Psycho-galvanic reaction	5	2.70
12. Electromotive phenomena	4	2.15
13. Electrical processes	3	1.57
14. Psycho-electrical phenomena	3	1.57
15. Galvanic deflections	3	1.57
16. Psychogalvanism	3	1.57
17. Electrical changes	3	1.57
All others	41	22.20
Total	185	99.82

TABLE III

TERMS USED HAVING MORE OR LESS DEFINITE PHYSICAL OR BIOLOGICAL MEANING

Term	Number	Percentage
1. Electrical resistance	23	12.42
2. Electrical potential	12	6.50
3. Electrical conductivity	11	5.95
4. Polarization	9	4.90
5. Capacity effects	2	1.08
6. Bio-electric current of the skin	1	.54
7. Skin currents	1	.54
8. Skin magnetism *	1	.54
9. Skin potential	1	.54
10. So-called polarization	1	.54
11. Vital magnetism *	1	.54
12. All others (non-specific)	122	65.90
Total	185	99.99

* There is some doubt as to the meaning of these two terms.

deflections of a galvanometer or pointer readings with such complex responses as those included under the term 'emotion' can hardly be justified scientifically. To assume the nature of such changes is equally hazardous. From the above classifications it seems to the writer that some significant general term should be adopted for the purpose of categorizing similar

studies of this nature. In addition, it is further suggested that each investigator determine exactly what his field of experimental approach is to be and to adhere rigidly to methods of physiology or the physical sciences in the controlling factors involved. In addition psychological factors must be kept constant. If resistance changes are to be the chief matter of investigation, the techniques involved should be mastered. If potential differences are of greater interest, suitable methods should be developed and standardized. In any case the descriptions should indicate clearly the controls used.

The same would hold for conductivity, polarization, and capacity. The latter two have not been sufficiently studied. When a number of investigators have become proficient in their respective fields a collaborative research should be carried out to determine relationships.

The term 'psycho-galvanic reflex' is certainly not adequate. The phenomenon is largely non-psychic in nature, only at times is it galvanic and there is considerable doubt as to whether it is a reflex. It is more probably an organic response of physico-chemical nature which may be either inherited or acquired. The electrical phenomena are merely of secondary importance since there can be no chemical change without some accompanying electrical changes, if such are to be distinguished. The most satisfactory name would definitely describe the phenomenon in its proper relation to psychology and would remove many of the objections to common usages which are evidenced by the widely varying terminology. The name *electro-bio-chemical response* is suggested to supplant the term *psycho-galvanic-reflex* or any of its numerous variants. Under such a heading the respective contributors might designate a certain study as, 'the relation of changes in electrical resistance to fatigue in electro-bio-chemical responses of adult humans,' etc. By describing the method carefully and calibrating the apparatus in standard ways there would likely evolve a much more consistent body of data relative to the general subject. True there is no intrinsic magic in a name but on the other hand science proceeds more rapidly when its

symbols become highly specialized. Therefore, perhaps a term more nearly describing the actual known changes taking place would be more generally accepted.

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[Ms. received January 9, 1931]

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